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USER EXPERIENCE STUDY OF 360° MUSIC VIDEOS ON COMPUTER MONITOR AND VIRTUAL REALITY GOGGLES

Master of Science Thesis

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ABSTRACT

MOHAMMAD MUSHFIQUR RAHMAN REMANS: User experience study of 360° music videos on computer monitor and virtual reality goggles
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In the past few years, user experience has become a trend in the field of Human-Computer Interaction (HCI). The ultimate success of a product or service depends on delivering user experience as the user prefers. 360° video is an immersive technology that offers a new era of visual experience. People are using 360° videos in several sectors of their everyday lives, including media consumption such as music videos.

Nowadays, Virtual Reality (VR) and 360° camera hardware are becoming more usable, and 360° videos are also being produced to deliver realistic experience through both VR goggles and traditional displays. While producing 360° videos, the need of measuring user experiences also arises.

This study explores the user experience of 360° music videos along with how the users perceive multicamera 360° music videos through the computer monitor and the VR goggles. This empirical research was conducted in the form of a laboratory experiment with 20 test participants. During the within-subject study, participants watched four 360° music videos produced with four different cutting rates and shots and then evaluated them. Quantitative and qualitative data were collected through user evaluations and interviews. The data were also analysed both quantitatively and qualitatively.

The results indicated that a music video which was produced through integrating eight shots (average length of 26 s per shot) captured by four 360° cameras, delivered the highest quality user experiences on both computer monitor and VR goggles. The video which had the highest cutting rate (average length of 11 s per shot) delivered lowest-quality user experiences. Results also demonstrated that 360° music video which was produced by using a single camera delivered some boredom among the users because of its static view. The thesis is concluded by illustrating the findings of 360° music video user experiences based on user evaluation and interview data.

PREFACE

First, I would like to say great thank to Professor Kaisa Väänänen, you have supervised my work and guided me all the time whenever I have encountered any difficulties even though you had a lot of other works to do. Without your support, it was not possible for me to complete the thesis work within due time. I remember the first day when we meet and discuss the topic and the opportunities, I am delighted that you choose me for such an important research topic. Moreover, thank you for all the support and guidance you have given me. During my thesis work, I have learned a lot from you and this knowledge will help me till rest of my life.

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Tampere, Finland, 08 December 2018

Mohammad Mushfiqur Rahman Remans

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LIST OF SYMBOLS AND ABBREVIATIONS

VR	Virtual Reality
360°	360-degrees
UX	User Experience
3D	Three-dimensional
CGI	Computer-generated imagery
TV	Television
VBL	Video-Based Learning
HMD	Head-mounted Display
SD	Standard Deviation
SEM	Standard Error of Mean
4K	Horizontal display resolution of approximately 4,000 pixels
HD	High Definition
ANOVA	Analysis of variance
α	Alpha (significance level)

1. INTRODUCTION

According to Oxford dictionary, Virtual Reality (VR) is “The computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors” [1]. VR technology offers an attractive opportunity for high-level sensory experience also proved that its useful as it has a wide range from the interest of an enthusiast or hobbyist, eager student till a technology expert. It has been used for a variety of purposes such as [2] travel, education, entertainment, industrial applications, medical use, and consumer retail also. The travel industry has been using the VR technology for tourist attraction purposes [3]. In health care field, VR technology is used for diagnosis and treatment of patients through computer-generated images. In education field, VR technology has been used to spread awareness. Toyota is using Oculus headsets to spread awareness among teenagers about distracted driving. The growth of VR applications to the entertainment world is also surprising. 3D 360°(360-degrees) videos were also found as highly suitable for VR technology.

A new wave of immersive experiences corresponding 360° videos I s exploding up everywhere that brings a new era of visual experience. 360° videos are also viewed on regular monitors and VR devices. 360° videos mass market is growing since it increases the impressiveness and helps the viewer to perceive the whole content; the viewer also experiences the whole video atmosphere in a way that associates more closely to real life experiences. Multicamera 360° videos bring opportunities for the audience to enjoy the whole video from different positions. 360° videos are specialised with multi-camera apparatus that can capture 180° (vertical) x 360° (horizontal) field of view, where the traditional videos have a limited view. These 360° videos can deliver extremely immersive experiences[4] that trigger user's sense of presence[4], engage their sensory elements and allows to focus on the video’s content while the viewer feels physically present in the environment.

While using a digital product or technology users go through some direct or indirect experiences, this is usually known as UX (User Experience). This theoretical concept of UX is ingrained from the field of HCI (Human-computer interaction) [5]. Some aspects of digital product or technology such as learnability, usability, usefulness, and aesthetic appeal work as a critical factor in users' experience of the product [6] which is referred to customers actual needs [7]. For 360° video, these factors are mainly pleasantness, impressiveness, illusion, the flow of story, engagements and attentiveness to the viewers [8]. UX is also found as measurable because it has a wide range of experiential qualities

[9]. However, testing the user experience of this new environment brings new thoughts and challenges. It has been said that different users have very different thresholds that would lead them to a different type of experiences.

Though the Virtual Reality concept is not new, recently it is going to be fully realised, while it is being more immersive and interacting. Nowadays many devices are available in the market that uses the user's mobile phone as well. While incorporating with these kinds of new tools for UX testing, it raises some important considerations. The researcher has chosen this filed because the researcher has seen users being so amazed while they are experiencing 360° videos. The users consequently feel more immersed when they got the chance to experience 360° videos in Virtual reality devices. This new technology makes people feel like a physical part of the environment. The researcher holds a strong belief that 360° videos and VR technology can change the way of enjoying multimedia contents.

1.1 Purpose and Research Questions

In recent days VR and 360° camera hardware are becoming more usable for the mass market, and 360° videos are also being produced along with the regular videos to deliver more realistic experiences, it is also crucial for the 360° video producers and editors to know how the users perceive multicamera 360° videos through the regular display and also for the VR goggles. The purpose of the research is to investigate the user experience of multicamera 360° videos by using computer monitor and VR goggles. The research will also explore how do users perceive them. More specifically, the research investigates how do most users perceive four different versions of multicamera 360° videos produced with different cutting rate and number of shots. The study also investigates which factors affect the way of cuts. The tests were done with one type of music videos. As test materials, four different version of music videos were produced from Finnish popular Roc band Popeda's 40th-anniversary concert [10]. The concert took place at Pakkahuone, Tampere in December 2017.

The research questions are:

RQ -1a: What kind of experience do people have while watching 360° music videos?

RQ -1b: How do users experience 360° music videos on a computer monitor and VR goggles?

RQ -2a: How do users experience the different cutting rates of the 360° music videos?

RQ -2b: What are the optimal cutting rates for both Computer Display and VR goggles?

Therefore, the study results could make a significant influence on 360° video production and VR industry, since 360° videos are being adopted by the mainstream and mass-market (Facebook video, YouTube, Blogs).

1.2 Structure of The Thesis

This thesis work is prepared in 6 chapters. It starts with the background of VR and 360° video user experiences. Then, it focuses on the background of UX, deliberates about the opportunities and challenges of the thesis theme and directs to the research questions and purposes.

Chapter 2 concentrates on the related theoretical background on multimedia experience and 360° video. Precisely, it is divided into three subsections. Firstly, it discusses the multimedia experiences in different sectors. Secondly, it explores the detailed background of 360° videos which are related to the thesis theme; thirdly it presents the related terminologies and earlier studies on 360° video editing.

Chapter 3 illustrates the main methodologies applied in this research and the reasons behind using those methods. During the thesis, user evaluations and user interviews were conducted for quantitative and qualitative data collection. Quantitative data analysis was performed by ANOVA testing and Cross-tabulation analysis. Qualitative data analysis was performed by thematic analysis.

Chapter 4 demonstrates the quantitative and qualitative analysis results based on the findings from users' evaluation and interview questionnaires.

Chapter 5 contains the discussion part, which mostly reflects the overall summary and findings of the research questions also the limitations of the thesis work.

Chapter 6 discusses with the conclusion of the thesis. It mainly discusses the factors which affects the user experiences while consuming 360° music videos in computer monitor and VR goggles. Furthermore, it also discussed the vital UX aspects that need to consider while editing a 360° music video.

2. THEORETICAL BACKGROUND

This chapter presents the central areas of earlier work related to the thesis topic. First, the research concentrated on multimedia experiences, its evolution of recent years and how multimedia are affecting audience feelings and emotions. The research also explored how multimedia is effecting in different industries. Second, the theoretical background concentrated on 360° multimedia technologies and 360° videos. The research also explored the use of 360° videos as an entertainment tool in different immersive technologies. Third, the research concentrated on earlier studies which exposed the concerns and thoughts of 360° video editing. Especially the research explored the essential factors and considerations along with 360° video editing process.

2.1 Multimedia Experience

The multimedia content refers to the materials which are created online for information and spreading awareness. The platform uses different types of tools to present content such as video, animations, movies, presentations, and much more. The ambit of multimedia has been spreading to different prospects within the world. The multimedia setups have been widely acquired by people because of their emotional abilities. The emotions define how these people can relate to the content. The multimedia has the power of attracting the attention of people with relevancies. This power means when people watch something relatable; they automatically become attached to the content. The second major effects fall onto the entire user experience of multimedia within the industry.

In the years of development, the multimedia industry has grown amazing heights within the world. The heights cover different avenues of involving voice, text, and different kinds of graphics as well. The multimedia industry has grown into a million-dollar idea with investments being pooled in from different companies. The major impacts of the industry relate to how it has changed the overall print media. The researches within the relevant fields of this industry have shown how the print media has vanished [11]. The vanishing refers to how companies prefer digital marketing features as compared to newspapers and other forms of texts.

Multimedia marketing approach has been produced to overcome the limitations of text marketing advertisements. This evidence can also be found within several other fields of research [12]. The market analysis reveals that the social media incorporation of multimedia has directed to its fame [13]. The advertisements created by companies are shareable and can be monetised as well. The easy sharing facilities and mediums allow

the companies to make short ads on their pages. The feasibility of watching such adverts has become easy due to mobile application developments.

One of the major factors for the popularity of these systems is the user experience through multimedia. These experiences have been known to support the content and become engaged with the overall materials. The users also feel the experience of 3D movies which makes them feel the similar environment being shown on the screen. These experiences increase user satisfaction levels as well. The companies also become the symbol of innovation by improvising user satisfaction techniques. These techniques involve various surveys conducted to analyse the needs to the users. The analysis also helps to place the brand in the market and to choose a correct marketing mix for the product. User satisfaction is also accessed with the help of Total quality management techniques. These techniques define unity and coherence between communications which can be achieved by Multimedia setups [14].

The multimedia usage is defined as the adequate flow of information from different sources to the end users. The end users benefit from these sources in different arrangements and services thoroughly. The media industry has been formulated based on different innovations and technologies. These technologies involve the creation of films including different CGI (computer-generated imagery) effects, animations and various transitions as well. The multimedia tools are also used to edit these movies and to make them with complete quality control.

The media industry has been seen an impressive field which has started to produce various kinds of content in the world [15]. The primary usage and importance of this industry lie within providing entertainment to the customers. These entertainment procedures have also been escalated with innovations and technologies.

2.1.1 Multimedia in Education

The compensation and usage of multimedia within these fields have caused its emergence to be in several other industries as well. These industries have capitalised the usage of multimedia projections and tools to allow different facilities. One of the first industries which can be accounted for usage is the educational sector. The educational sector is diverse, and its sub-sectors are related to one another in multiple ways.

One of the potential reasons why this sector is appreciated is because they have many branches and levels [16]. Students enrolled within these educational institutes have to go through various phases. The phase requires to study different course material over time. The research within the field of education shows the popular interests to accumulate technology within courses [17]. This process involves using different multimedia assets in the order of the course. The overall usage is based on different factors and has various pros and cons within the field. The framework of inculcating technology based

on multimedia within educational institutes depends on the teachers. The teachers have the responsibility of designing their course materials. The course materials are made in order for the students to learn them and in natural languages. The essence of these courses depends on how the teachers design them for the students in the class. The multimedia projections are then used for sending different subjects within the classrooms.

Different empirical studies have shown how students were comfortable with slides and presentations instead of course books. Many students within the survey highlighted to how book reading like a bulky task which lost their attention [18]. The second major actions regarding multimedia usage have been in the form of E portals assigned to the students. The E portal is an electronic interface which provides access to a broad range of information [19] that helps the students to sustain their courses and assignments whenever they want. The teachers have found new and innovative methods of using texts and videos which provides comfort within the instructions [20]. The assignment instructions are often demonstrated on screen recording applications. These videos are then sent to the students in order to make them understand.

The multimedia level education has also been formulated into complete degree programs because of their importance. These degree programs are known as mass communication and media studies which enable the students to learn filmmaking. The overall courses also teach the students regarding the further usage of design and animation tools. These courses and techniques are helpful for the students within the mainstream industries because it adds variety within the markets and increases the chances of quality content to be developed [21].

Video-based learning (VBL) technology uses video technology to share knowledge and skill [22]. It became more popular during the past few years with a variety of online courses to provide remote education and experiences. It has been used for open university education and different e-learning communities also. Nowadays many educators, and bloggers are using different video sharing tools like YouTube to spread out their knowledge and to provide various training. Immersive technology that engages users' sensory experiences can increase this engagement more [23]. Immersive technology like 360° video and VR appealing users' sensory experiences and increase engagement that makes users feel interested in the content and environment [23]. Research also showed that students could be present in the simulation without being actively conscious of the content and absorbing the learning content by engaging themselves with the technology [24][25].

2.1.2 Multimedia in Business Communications

Other important sources of multimedia communication within different places involve their usage within the business fields around the world. These organisations are mainly developed on the basis of providing customer services. The customer services present

different products which are aimed towards enabling better communication. The business fields which mainly operate under multimedia communication involve marketing organisations. The recent developments have shown that these media services have spread to other places as well [26]. The simple organisations producing other services have also chosen for the use of multimedia. The major reason for these industries to have chosen multimedia is because it provides complete facilitations. The facilitation includes representing the company operations and developments.

The multimedia concepts used in business have evolved into various types of products and tools. One of the popular tools includes virtual simulation software that incorporates calculations and projections. These tools are employed by the high-level managers to show the company's future projections as well. In the simple concept, the companies can find their future standings based on their current data. The use of multimedia technology helps the organisations' managers to improve the data by eradicating all the ambiguities visually.

The overall scope of the technology has also been found to be transmitted within the internal communication of the companies. The internal communications represent to how the employees exchange information within the organisation. The information exchange is also known as knowledge management in the company. These experiences involve the transmission of different memos and instructions to the employees. Multimedia tools have greatly improvised the organisational communication system. These tools also make use of various mobile applications as well.

The overall usage of these sources enables the organisations to save its time. The time factor is crucial for large companies because it supports productivity and work efficiency. The essence of quality management and control depends on how the companies manage their tools and integrate them within their tasks. These tasks also involve the facilitation of customers and employees in various departments.

2.1.3 Multimedia in Medical Science

The multimedia has also found efficient ways to be incorporated within the medical institutions and fields as well [27]. The medical fields have been rising over the world because of their contributions to society. These contributions mainly include the smooth production of medicines and cures for diseases. The overall medical field also employs various kinds of doctors who are available to serve people at different time slots. The multimedia has found its way into the industry by allowing better observational studies [28]. Doctors use multimedia by showing visuals to the patients and colleges for further analysis. These visuals firstly include the computed tomography (CT) scans, and magnetic resonance imaging (MRI) scans of the patients. These scans allow the projections of the patients' bodies to be projected on special papers and displays. The doctors then study the projections in different ways to formulate a conclusion.

The researchers within the medical world [29] have highlighted how these media services have improved functionalities [30]. Another benefit of multimedia is the usage in various surgeries and operation routines. The cameras have been developed to provide different facilitation to the doctors during surgical procedures. These medical cameras are custom built to be small-sized and hence provide High Definition (HD) quality images. The images are then stored onto a large screen and hence used by doctors during surgeries. The image processing during operations is also a useful technique because it provides help. The help is in the shape of observing minute and delicate veins within the body. The doctors have estimated how this has increased their performances and efficiencies within the working environments.

2.2 360° Multimedia Technologies

The recent trends within the world have shown how the innovations in the field of technology have created various inventions. The major evidence in the multimedia industry lies within the creation of 360° cameras. These 360° cameras are special ring of multiple cameras or multiple camera lenses are embedded into one device [31] which produce the power of capturing complete images of a plane. This also means that the 360° cameras allow the complete image to be processed within panoramic views. The panoramic views were ideally introduced within different smartphones. These inventions showed the idea to take off and to attain the general view of the public. The technology was soon improvised to new dedicated cameras built for these purposes. The overall effects created by these cameras allow designers, film creators and content creators to gain the attention of people [32]. The audiences attracted by these cameras are captivated by the still imagery. The transmissions of the cameras are sent to different communication channels such as computers, mobile phones, and even social media channels. These cameras are valid proves about how the multimedia projections and technologies have improved. The innovations within these fields have allowed better and fast content creations. These innovations have also inspired different people to become bloggers and social media content creators [33]. The popularity of 360° cameras has encouraged popular websites such as Facebook to incorporate these technologies within their systems. The social media sites allow live streaming through this camera.

2.2.1 360° Videos

360° videos are emerging technology that gives audience a new viewing experience by deeply involving them to the content. 360° videos offer a new live experience where the audience can have a complete view of the scene by rotating the video in any direction. It takes place from the perspective of the camera just like in traditional cameras. 360° cameras are now widely available and used because of its increasing trend [33]. It produces a realistic view which promises the feeling of being present at the content environment. 360° videos were also found as time efficient to perceive. They provide a live

experience to the viewers that make users' feel more attached to the story. It facilitates effortlessness for the spectators.

360° video recording helps the viewer to experience all dimensions of a movie or a video at one time. The 360° video is created by attaching six to ten 360° cameras with a 3D printed mount that focuses separately in a different direction [8]. It is difficult to attack so many cameras to achieve the purpose, that is why some companies have cameras with multiple lenses. Such companies include OZO, Jaunt, and Insta. The combination of 360° cameras small body and wide-angle lens provides a perfect shooting opportunity of 360° video.

The well-known 360° camera manufacturers are Nokia OZO, Jaunt and InstaPro 360, GoPro, Ricoh Theta V., Detu Twin, Samsung, Yi 360 VR, Kodak, Shenzhen Arashi Vision Co., Ltd, Garmin [34]. When the joint footage associates with more than 360° it creates an overlay that is important when stitching the footage together. Another special feature of 3D video is that the viewers can feel as a part of the video which makes it more real and enjoyable. Another benefit is that the viewers can view it from any direction they want. Thus, the viewer has more control over the video. Figure 1 illustrates some latest 360° cameras.

Figure 1. *A picture of different 360° cameras [71].*

However, there is one evident problem in this technology. The cameras have some issues as crashing, poor connectivity, or poor functionality. Not only no-name brands but also well-known brands like Nikon have this problem. Though these cameras offer some working app, people want to use Adobe Premiere or Final Cut anyway because they are already familiar with those applications also because they are much better than the cheap software that may (or may not) come with the cameras. However, in reality it should be improved a lot more. It should help to edit or trim clips, create videos within the app and even do a degree of photo editing [34].

2.2.2 360° Videos as Entertainment Tool

Nowadays 360° video has also become an influential entertainment tool. It brings new opportunity for viewers to transport in faraway places with a new immersive experience and allow them to perceive and interact [34] within the video content in a more entertaining way. Because of the rising popularity of VR, music lovers are also getting familiar with this new technology, and 360° videos are changing the policy of entertainment sharing. Through this particular type of video, artists get the opportunity to share visual and rhetoric art which gets more attention from the audience.

Many music bands have chosen the 360° videos as a performance sharing way and to encourage their new tracks. One of the British rock band 'Muse' has been investigating VR videos for their concerts from past years and initially providing VR-friendly video of their concerts. In 2016 they produced their big-budget 360° video for the track 'Revolt' [34]. Several bands like Avicii, Björk, Foals, and One Republic also produced 360° videos that become hugely popular [34].

360° video provides a new opportunity for the fans to enjoy their favourite concerts and festivals remotely from anywhere. These interacting videos are not only placing the viewers in the concert but also can place them right on stage. Smartphones are one of the essential technologies of our everyday use. The easy availability of the VR technology and VR compatible smartphones is growing the peoples' interest in the interactive contents. Users are being amazed to VR day by day, and a various number of better 360° contents are coming up to thrive around the world. 360° movies have a great prevalence in Box Office. From 2015 to 2018, 360 entertainment movies gross approx. 168,673,264 USD [35].

Earlier research also investigated on the audio production of 360° videos to achieve musical balance in transitions between on-stage and off-stage cameras. Holm J. and Malyshev M. presented two spatial audio production workflows for spatial audio mixing after a series of case studies on pop, rock, and orchestral music [10].

2.2.3 360° Videos in Virtual Reality

In 1950s Morton Heiling [36] wrote the "Experience Theatre" that engages viewers in all the senses more actively and effectively. He is believed as the pioneer of VR who made the first VR prototype named as "Sensorama" [36]. First VR was used by U.S military to simulate different pieces of military training among the soldiers, also to navigate real cities [37].

Nowadays, almost all industries are adopting this technology because of its high potentiality [38]. Virtual reality becomes increasingly popular since the revolution in emerging Virtual reality software and hardware also in head-mounted displays (HMDs). Vir-

tual reality display normally splinted between user's eyes to generate an impression of depth and solidity to make the content more immersive and realistic. Head-mounted VR devices are getting more popular and potential interest on 360° videos. The conventional videos limit the viewer's point of view, while 360° videos are more interactive and allow transporting within the virtual environment. It also gives the opportunity to watch through the given scene with the freedom to look [39] at any direction of the moving image. 360° video provides better realistic perception while integrated with 3D technology. Earlier studies found that 3D experience delivered a higher sense of perceived depth and perceived sharpness [39] [40] with a faster perception of depth [39] [41]and more exact size or shape of the 3D objects [39] [42].

During 2018, the most popular VR headsets are Oculus Rift, Samsung Gear VR, Oculus Go, HTC Vive, PlayStation VR and Google Daydream View [70]. Figure 2 illustrates some popular VR goggles.

Figure 2. *A picture of different VR goggles [73].*

For the beginner, VR and 360° videos appear to be quite similar. The major difference between both is, in VR the viewer is free to control the interactive environment which is developed by the VR technology. However, in 360° degrees, viewers are in an interactive environment but have no control over it, and they just go with the flow of engagement [43].

VR sickness is one of the critical factors that is still being investigated. It can always play an important role in the ultimate 360° video user experiences. VR sickness or simulation sickness mainly appears while there is some inconstant input between the human visual and vestibular systems [44]. Motion sickness appears when the human visual system gets input regarding stationary while other senses get input about moving [44].

2.2.4 360° Video on Big Screens

Earlier in 2015 YouTube started supporting 360° video streaming, with the opportunity to roam around the video at any direction and also bringing it in much larger TV screen [45]. In October 2016, a Disney-funded VR service application released for televisions using Apple TV named as Littlstar for 360° videos. It has fetched 360° videos and VR on many platforms including mobile apps, Gear VR, and TV also. Littlstar offers immersive and expressive contents from world's top content producers, including National Geographic, DiscoveryVR, USA Today Network, The Wall Street Journal, and more 11 types as well as Travel, Sports, Lifestyle, Animation, Gaming, and Documentaries [34]. Now viewers can enjoy a lot of 360° videos on the bigger TV screen. It also billed the first virtual community for 360° and VR videos that help the tech-startups in the entertainment sector. Along with VR goggles, 360° videos a game changer because it makes the viewer feel like they are really on the video environment, viewers can pick something new at every time. Viewers can select what they want to see, where to see and how long they want to see.

2.3 Editing 360° Videos

360° formats offer the video maker both opportunities and challenges. There are several difficulties for the editors or directors such as setting the camera angles, video cutting, focus adjusting and the camera moving techniques [46]. In traditional videos, filmmaker guides the audience through a narrative path to share the story. However, while using this traditional video technique in 360° videos, the user may have a negative experience and can reduce users' feeling of control [46]. Since one of the key benefits of 360° video is, the user has control over their own gaze [33]. 360° video maker must permit the user to control and direct their own gaze by using subtler, unobtrusive methods [46]. Along with the user control and freedom, the filmmaker also needs to direct the viewers' attention by using a better quality of sound, lightings and movements [46].

However, there are major concerns about the effect of the pacing of video on engagement. The producers have started experimenting with cinematography techniques to deliver a realistic version of the story [47]. Research has also found that the shots by 360° need proper alignment to share the relevant story content. The earlier versions of commonly used Adobe Premiere did not facilitate alignment as it did not have a proper tool for rotating. Brillhart manually aligns the shots while Nguyen introduced an in-headset video editor that helps in aligning shots [48].

In 2017, Tampere University of Applied Sciences (TAMK) produced 360° music video of 'Timo Rautiainen & Trio Niskalaukaus, Toisen luokan kansalainen' [49] which is held in Pakkahuone, Tampere, Finland on 18.11.2017. In this video, they placed the camera near to the instruments and used 360° moving cameras without producing any motion sickness among the viewers. In this video TAMK also used slow-motion screen

fading technique to make the content easily adaptable. The cutting rate of this video was based on the story and performance.

During the same year, an American heavy metal band 'Metallica' released a 360° live version of 'Seek & Destroy' which was filmed at 'Gillette Stadium in Foxborough, MA' [50]. In this video, they placed a camera near the musical instruments, which gives a view of both the band and the audience. While watching the video, viewers can feel like being present at the concert. For another two videos 'Tritional and Jean-Michel Jarre' they used viewpoints-oriented cuts for allowing more powerful illustration of the experience [34].

2.3.1 Editing Goals

It is important to understand the main aim and goal of editing. If a video maker is well aware of his goals and objectives of making a video or editing it, then he would implement it in a better way. Thus, it is important to understand the goals of editing before getting started with it.

- The primary aim of editing is to highlight the story and align the sequence. This will make the video easier to focus on more technical and time taking effects and graphics [51].
- To maintain the orientation of every shot in the viewers' mind. It gives the perspective of what will draw viewers' attention.
- To lining up the shot so that the next one appears right where the viewer was looking on the earlier shot.

2.3.2 Prerequisites for Making 360° Video

Editing 360° video is always not an easy job. Editors and filmmakers follow several guidelines while making an enjoyable and pleasant video. Several earlier studies have investigated those guidelines and prerequisites to make excellent 360° videos:

Motivations for 360° video shooting

While making a 360° video, there should be a good motive to give effort. If one is aiming at enhancing the experience of a particular story, it is the best idea to shoot in 360° format, because it provides unique experiences. Also, if the editors invest enough time, it will be more feasible [51].

Moreover, 360° video makers should also make it easy to use. Sometimes it takes an entire day while shooting and observing the shot correctly. So, one must decide beforehand the time required for a specific project. It all depends on the amount of footage one wants to film, whether it is a full day or need extra time [51].

Must be allowed in all directions

That type of content should be picked which creates a sense of autonomy [52]. The camera should be handled in a way that the user can look everywhere within the content. If people stick the 360° cameras in the middle of a room, sometimes it gets monotonous. In some cases, this can be the best marketing technique as it gives customers a virtual experience. For example, a car company can take advantage of this technology as it will help customers have a virtual experience from the inside of a car.

Accessibility and versatility

During the selection of camera, one must consider the reason where they are going to use and share the video. Moreover, the budget is also an important aspect. It also needs to be innovative to save the cost and time. It is not necessary that adding extra details will make it more efficient. The camera just needs to be accessible and versatile [53].

Stitching various scenes into one video

After recording the video footage, dealing with hardware starts. As 360° videos have a higher resolution, the processing machine must have a vast power to handle it. This means it should have a larger RAM and processing power. The stitching depends on various factors. For example, if the video is a single cut video then how the objects are located in the video is an important factor. Another crucial factor is the number of scenes in the final video [43]. Different camera manufacturers set their own software that is customised to the details of the camera [54].

Medium selection

With the increasing competition in social media, Facebook, YouTube, and Google Cardboard are making good use of 360° videos. These platforms are very beneficial for marketers if they use it with a proper strategy. It is also important to be aware of the behaviour of the target audience. Before selecting the medium, the marketers must conduct valuable research of where the people are spending most of their time on and through what devices [51].

Navigation in 360° videos:

In the field of virtual cinematography, several previous studies investigated virtual camera control in rendered scenes [63] [64]. Several studies investigated the use of automatic real-world camera control in the context of remote meetings [65] [66]. In 2017, Serrano et al. studied how viewers understood a video edited with different shot alignment [67]. Pavel et al. in 2017 studied user shot orientation controls, either based on their current viewpoint (viewpoint-oriented cuts) or by letting them press a button (active reorientation) [47].

Viewpoint-oriented cuts:

In viewpoint -oriented cuts, focus automatically reorients the shot in every single cut on keeping the most compelling content in viewers current field of view. Viewpoint-oriented cuts allow the viewers free exploration to the content, but the filmmaker needs to ensure that, after every cut, the viewer gets the most compelling content of the shot [47]. This way it is possible to reduce the chance to miss essential story elements while viewers are searching after a shot change [47].

2.3.3 360° Video Editing Process

Editing 360° videos are entirely different from editing traditional videos. There are some proper steps that editors follow for an appropriate 360° video editing.

Stitching

While shooting a video with 360° technology, one needs to stitch many shots into a single video before entering the editing process. Otherwise, it is hard to visualise several shots as a story. Starting with the rough stitches and making changes after testing it or so. For saving space, it is best to have rough stitches at comparatively lower rates [54].

Editing

The most common and professional software used for editing in Adobe Premiere Pro. It supports 360° previewing also. Moreover, Premiere Pro, Vimeo and Adobe After Effects make a perfect combo [55]. All the basic concepts of standard video and 360° video editing are same which includes cutting, syncing, dissolves and levels. However, if one wants to add special effects for better graphics, 360° video editing is a better idea [56].

Previewing

Premier Pro helps to preview 360° videos easily. One just has to drop the equirectangular video on the timeline and go for the "Toggle VR Video Display" button in the menu [54]. After selecting the button, the camera will pan or tilt with the help of a mouse or the dials.

Exporting

While other steps for 360° video are quite similar to the standard video, exporting 360° videos are different from the standard one. The editor has to add proper metadata to the video. It has a simple process. After uploading the media file from the file menu, one just needs to export the file, and the system will lead to an expert panel. Then editor can set the video settings according to the requirements. There was a recommendation to use

a less compressed format as the 360° video which emphasises compression artefacts. It is best to use 4K because higher is always a good idea. This means that with a raw file of 4K, the part that exists within users viewing angle will be closer to 1080 [54].

2.3.4 Considerations of 360° Videos

Past research also found some important factors and considerations and features of 360° video. All these factors are related to the end users' experiences. Carefully taken care of the considerations and factors while editing 360° video can produce a great user experience.

Viewing Formats

One must be clear that experience varies from user to user. There is a difference between watching a story in a theatre with a hundred other viewers and experience the same story in a VR all alone. It gives a different kind of experience where the user can modify the viewing instructions and stuff. The user can also adjust the zoom level. Despite all the advancement, a standard format is still missing which suits both monocular and binocular modes have a standard resolution and have a user control. Story displayed on a theatre screen does not offer each member an individual control of interactivity. On the other hand, VR lets the user control everything from directions to pause intervals [52].

Field of View

In traditional VR photography, the viewer prefers a 360° ×180º view as it lets them take as much time to discover the scenes in detail. The viewer can change the directions, zoom controls and move to the other view. However, these kinds of VR images are still similar to a picture or painting. This helps the viewer to spend time exploring the details until contended [53].

On the other hand, motion imagery is entirely different. The video enhances the aspect of time in the story. An editor who works as a storyteller tells the limit of time and sequencing. This is because too much authority for the viewers results in ignoring the crucial parts of the story [53].

Limit of user control

For a traditional action sequence, there are chances that camera orientation and composition might change fast. This means that a camera and the shots must follow the actions. The editor or storyteller defines the time limit, composition, viewpoint, direction, and the perspective. If the viewer is allowed to have control over any of this, this will entirely change the resulting story [53].

On the other hand, current VR systems hand over the control to viewers which let users look at any direction at any time. There are various point of views about this strategy. It is also believed that it puts much responsibility on a viewer as in he has to figure out where to look in that time. If a user goes wrong, they may miss important parts of the story [52]. To avoid this problem, VR video is designed in a way that automatically takes viewers back to the story when it is needed.

Making Interactive

Motion pictures and video production are very intricate. The complexities amplify when both are merged jointly. VR photographer shares experience with the development team for original VR program development. This collaboration aimed to let viewers have an amazing experience of visiting places without even visiting them in real. The users could walk through the place. The programming involved a complex process with the help of best tools available at that time. The amount of content was huge that needed to be aligned properly [53].

Later on, Terry Beaubois a well-known founder of RDC Interactive appreciated the efforts of Masco and the quality of his project [53][52]. Although it was an exceptional technology at that time, a little resistance was found by users. All they wanted was a little guidance as the technology was their hidden need. The way how VR used to be promoted has now changed.

Filming Technique

Interactive screens require a particular field of view with some technical considerations [52]. Such as, use of shaky cameras need to be avoided since the interactive video needs to be clear and well defined. With a continuously moving camera, there comes a conflict between visual cues which gets confused in the users' mind. This results in motion sickness which is an unpleasant effect. Some movements are fine as long as they are controlled within limits. They should be silky smooth though. Making viewers feel ill would make them lose interest in the story. This will create a bad experience for the users. Using stabilisation algorithms in the VR software can be a solution for this issue [53].

The quality of images must be good enough and way better than traditional web video. The resolution must be good enough to present a pleasant view rather than causing stress. Moreover, lighting and exposure also need to be controlled appropriately. Higher display frame rates are considered better than the conventional frame rates [53].

The camera alignment and stitching software should be of top-notch quality. It is very disappointing when the viewer explores around the video, and it follows with stitch errors or some misalignments. This needs to be eliminated by having proper synchronisation between cameras [53].

Coverage, white balance, and focal point also needs to be consistent between cameras. Moving graphics make these problems more conspicuous than still pictures [52]. The sound quality must be tremendous and directional. Also, the sound required proper co-ordination while recording and playing [53].

3. RESEARCH METHOD

The entire experiment procedure will be described in this section. Since the study plan and pilot test was done, many of the aspects have been changed. The pilot test was done to find out new limitations and problems. The limitations found from the pilot were improved and adjusted based on the needs for a better consequence.

3.1 Research Design

The research aimed to investigate the user experience on multicamera 360° music videos by using a computer monitor and VR goggles. The investigation focuses on, how users perceive 360° music videos in computer monitor and VR goggles. The research also compared the user experience of four versions of 360° music videos with four different cut rates. This evaluation focuses on which version and UX factors of the video carries high-quality user experiences and which version brings low-quality user experiences to the users. The empirical research was conducted in the form of a laboratory experiment with 20 test users. Users were assigned to the test conditions in a random order. Figure 3 shows the phases of the user study.

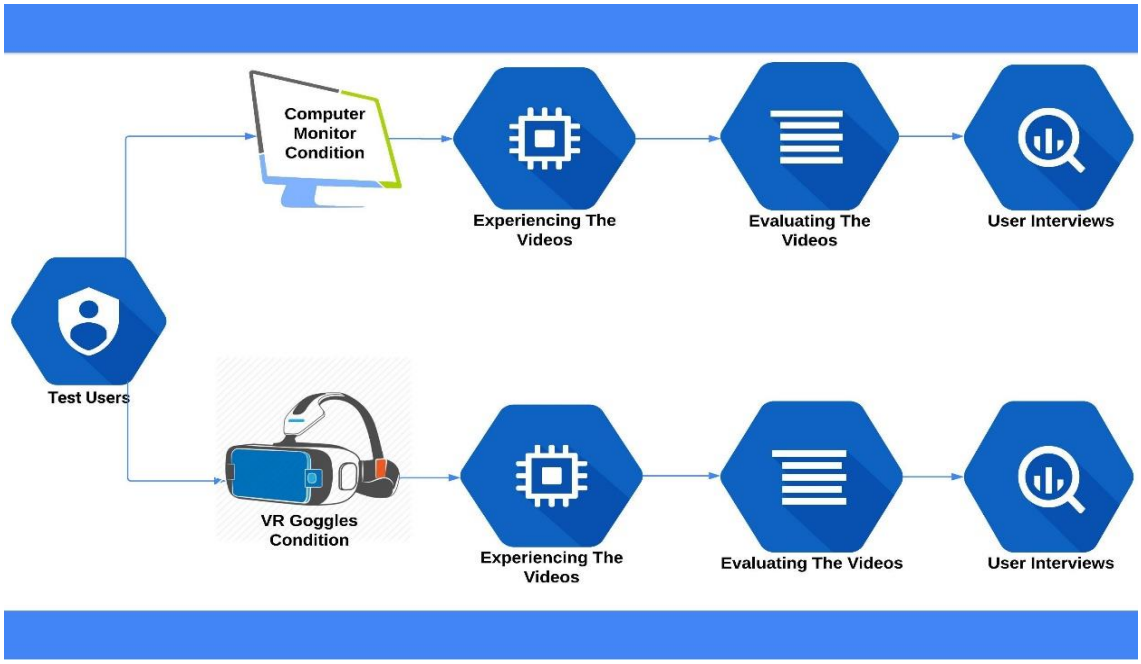

Figure 3. *Test phase diagram.*

The test consisted of the following phases; At first, the researcher received the participants at the experimental room and explained to them, what the experiment involved

with and how they would participate. Then, participants were asked to read and sign a consent form and to fill the demographic questionnaire. Then the participants were given a demo about what they are going to do during the study. During the study, the Participants were guided and helped to complete the tasks. While all the set up was ready participants started to watch all four videos. Videos were produced with a different number of shot also the cutting rate was different for each video. Participants watched all the four videos in computer monitor first, and then all four videos in VR goggles. The order of the videos was rotated during the experiment to minimise the order effect on the results. Subsequently watching every video, users were given some questionnaire to evaluate that video. For each test condition, Users evaluate the four different versions of 360° music videos one by one. After the user performed for all the four different versions of music videos, a semi-structured interview was conducted at the end of individual test condition. The think-aloud method was used to extract users' thoughts and feelings. Average experiment duration was one hour.

3.1.1 Forms and Questionnaires

Consent form: Participants were provided with a consent form to inform them about the study goals and objectives as well as their rights, risks and benefits. It was also guaranteed that the result would be reported anonymously, and their personal information will remain confidential. The consent form is in Appendix A.

Background questionnaire: Participants background information was gathered through a background questionnaire. Besides with basic demographic data, participants were asked about their prior experiences and similarities with VR and 360° music videos. The background questionnaire is in Appendix B.

To find out the potential answers to the research questions, two sets of questionnaires were formed. The questions were adapted from earlier studies [68] [69].

Evaluation questionnaire: Evaluation questionnaire mainly focused on how the user perceives 360° music videos in computer monitor and VR goggles. After the participant experienced each video, a set of questionnaires was used to evaluate that video. Questions were numbered from Q1 to Q7. For Q1 and Q2, the 7-point Likert scale was used to measure users' opinion about the specific video. Q1 focused on participants 'Music pleasantness rating', and Q2 focused on participants 'Overall video rating'.

From Q3 till Q7, simple 'Yes/No' questionnaires were used to gather more precise information in a well-targeted manner. Question Q3 focused on 'participant noticing the camera changes', Q4 on 'participants concentration losing', Q5 on 'role of camera changes for video flow enhancing', Q6 for 'feeling of being present', and Q7 for 'ability of active exploration'. The evaluation questionnaire is in Appendix C.

Interview form: Semi-structured interview questionnaire was used for interviewing the participants. After watching all the four videos arranged for each test condition, a semi-structured interview was conducted. Interview questions mainly focused on participants feelings, thoughts, experiences, and recommendations about the videos and test conditions. The interview questionnaire is in Appendix D.

3.1.2 Data Analysis Methods

The researcher selected mixed method approach to test the user experience of 360° music videos for computer monitor and VR goggles. The mixed method is also known as data triangulation which is recently a very used approach that integrates both the quantitative and qualitative data in a single experiment or study. This mixed-methodology allows a more complete and efficient way of data analysing, test conditions comparing. It was mostly used in the field of social sciences, but recently it expanded to different research areas such as medical sciences and pharmacy also [57].

Quantitative Analysis

The experiment was a within-subjects design where the same subjects perform at all levels of the independent variables. The analysed quantitative data were collected by the survey questionnaires. The same questionnaires were used for evaluating all the four different version of music videos in both the computer monitor and VR goggles condition. One-way ANOVA [61] and cross tabulation [58] analysis were done to compare the collected quantitative data. In the result section, measured variables were visualised with tables, bar graphs and boxplot representations.

Qualitative Analysis

Qualitative analysis was used to summarise the interview data. Audio data was collected from the interview session and transcribed into written form for further analysis. Thematic coding of transcribed data was done to find the text passages that were linked with a common theme. In the result section, the findings from qualitative data were reported based on the theme.

3.2 Test Participants

A total number of 20 participants consisting of 80% male and 20% Female were recruited from Tampere, Finland. Among them, 75% of participants' have a College / University degree and 25% have a High School / Other educational qualification. The participants' aged between 19 - 33 years with a mean of 25.05 and standard deviation, SD = 4.21. Table 1 describes the mean, standard error of mean, and standard deviation of the participants' background experiences and familiarities.

Table 1. *Participants' backgrounds.*

	VR Experience	360 ° Video Experience	Music Video Experience	Music Listening Experience	Music Playing Experience
Mean (M)	2.5	2.10	5.15	6.30	2.25
Std. Error of Mean (SEM)	.32	.27	.40	.31	.17
Std. Deviation (SD)	1.46	1.21	1.81	1.41	.78

According to Table 1, participants' VR experience mean was 2.50 (SEM= .32, SD = 1.46), meaning that the participants did not have much experience in VR. The 360° video experience mean was 2.10 (SEM= .27, SD = 1.21), which meaning that the participants did not have much experience in 360° video. The music video experience mean was 5.15 (SEM= .40, SD = 1.81), meaning that the participants had higher experience in music video. Music listening experience mean was 6.30 (SEM= .31, SD = 1.41), meaning that the participants had the highest experience of music listening. Finally, music playing experience mean was 2.25 (SEM= .176, SD = .78), meaning that the participants did not have much experience with music playing.

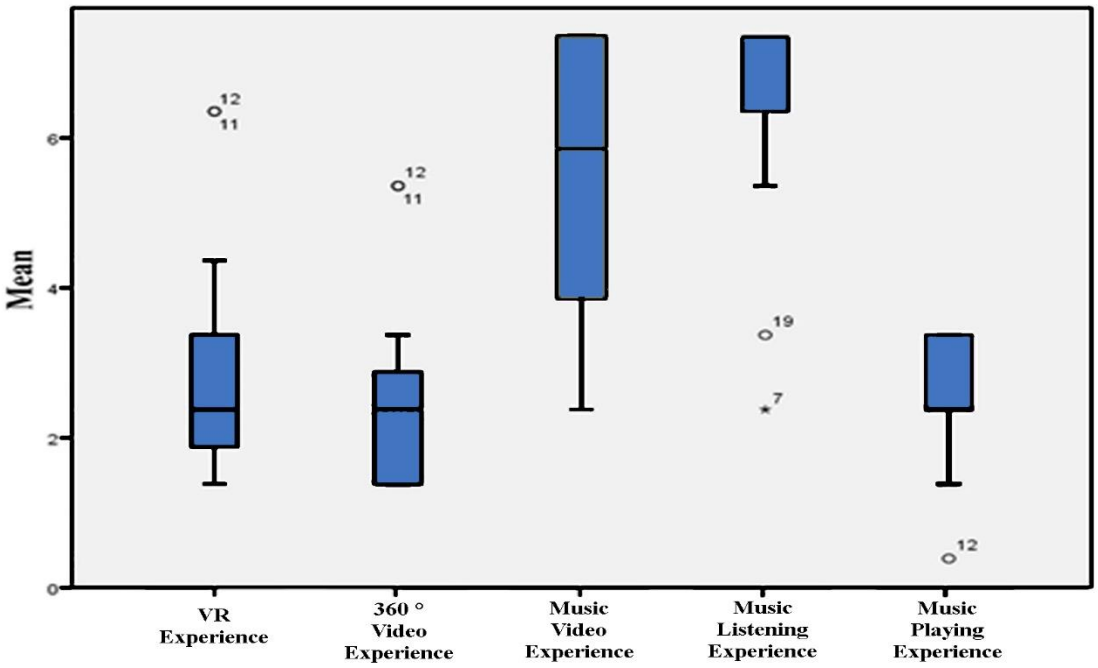

Figure 4. *Boxplot of participants' previous experiences and familiarities.*

Population standard deviation was used to summarise the results of the pupils attained as a mean, standard error of mean and standard deviation. Figure 4 above illustrates participants' previous experiences with VR, 360° video and Music. It easily demonstrates that the participants did not have many experiences in VR and 360° video while

there were two exceptions, but participants have much experience in music. Also, it is easily noticeable that the participants have a spread level of previous experiences and familiarities. This could be one of the limitations of this study because everyone was not on the same level when they were enjoying or experiencing some new technology.

Chi-Square Test was also conducted to find the correlations between participants' background and the variables, but no statistically significant correlation was detected since all the significance (2-tailed) p-value exceed 0.05.

3.3 Materials

Four individual 4K (3840 x 2160 pixels) resolution 3D-360° immersive music videos were produced for the study. Each of the videos consists of different rate of cuts (frequency of camera change) and a different number of shots (segment between the cuts), though the content of the four videos was created from same stage performance. Table 2 blew illustrates the four different version of 360° music videos with the number of cameras used, the rate of cuts, and a number of shots and the average length of shots. Stereo sound quality was used for all the four videos.

Table 2. *The four different version of videos with a number of cameras used, rate of cuts, number of shots, length of shots and average length of shots.*

Videos	Number of Cameras used	Rate of cuts	Number of shots	Length of shots	Average length of shots
Popeda A	1	No cut	1	3.25	3.25
Popeda B	4	1:12, 1:43, 2:46, 2:58, 3.11	6	1:07, 0:31, 1:03, 0:12, 0:13, 0:19	0:34
Popeda C	4	0:35, 0:43, 1:12, 1:28, 1:48, 2:00, 2:44	8	0:30, 0:08, 0:29, 0:16, 0:20, 0:12, 0:44, 0:46	0:26
Popeda D	4	0:35, 0:43, 0:48, 0:58, 1:03, 1:12, 1:22, 1:29, 1:48, 2:02, 2:12, 2:30, 3:37, 3:44, 2:54, 3:06, 3:12	18	0:30, 0:08, 0:05, 0:10, 0:05, 0:09, 0:10, 0:07, 0:19, 0:14, 0:10, 0:18, 0:07, 0:07, 0:10, 0:12, 0:06, 0:18	0:11

The experimental content was selected from one of the Finnish popular Rock band 'Popeda'. The content was captured from their stage performances of 'Helvetin Pitkä

Perjantai' held in Pakkahuone, Tampere, Finland on 02.12.2017. It was their 40th-anniversary celebration concert. 'Popeda C' was the official release that was published on "Popeda YouTube channel". The YouTube link of the video: "https://www.youtube.com/watch?v=uuD4fPOhNog&t=155s". Figure 5 and figure 6 below shows two snapshots just before and after a cut arise.

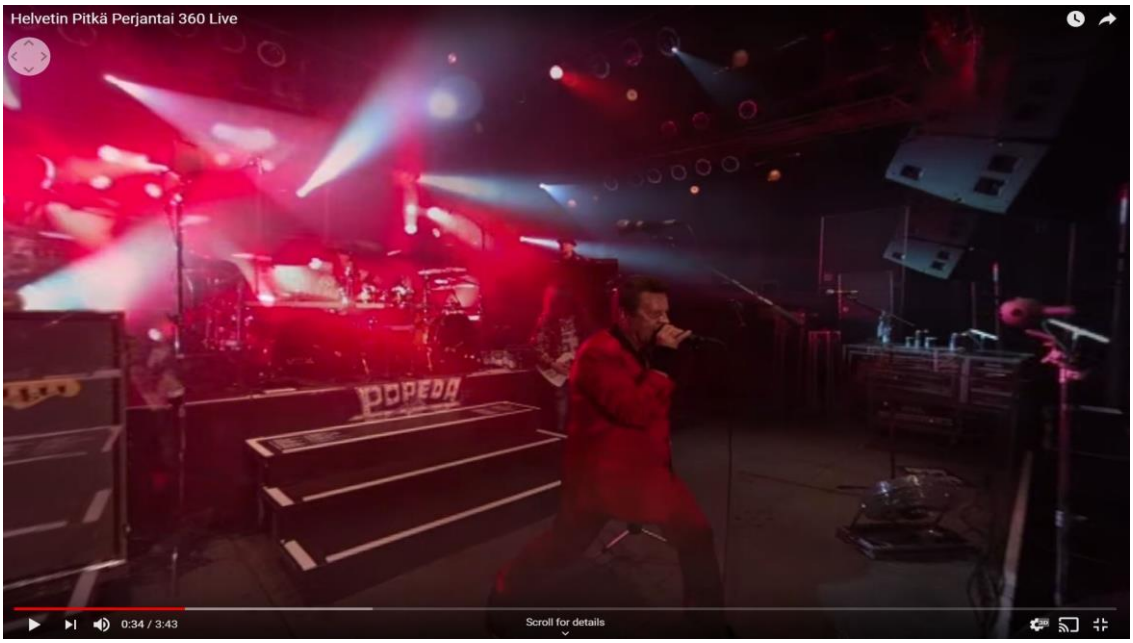

Figure 5. *Snapshot from 'Popeda C' before a cut.*

Figure 6. *Snapshot from 'Popeda C' after a cut.*

3.4 Tools and Experiment Location

The experiment was a within-subject design where each participant performed in every condition. The first test condition was computer monitor and second test condition was VR goggles. For computer monitor condition A 27-inch Lenovo Ultra HD 4K monitor was used along with a 100mbps network connection. For VR goggles condition two pieces of Samsung Gear VR were used with Samsung Galaxy S7 edge and Samsung Galaxy S8 mobile phones. For both test conditions, a Bose SoundLink Speaker III (Model: 414255) was used. A 5-meter 3.5 mm auxiliary cable was used both for computer monitor and VR goggles condition. Though the researcher could use headphones, then it would have been impossible to communicate with the test participants since the original plan was to do think-a-loud. However, very few participants were able or willing to talk while watching the videos. Also, in this study, the focus was not on the audio. During the study, the researcher tried to have equal audio volume for each video and each test condition so that it would not affect the results. The experiment was conducted at TC203, Tampere University of Technology, Tampere, Finland.

4. RESULTS

In this section, the researcher discussed the research findings based on user evaluation and interview data. The results are divided into several subchapters depending on the participants' answers to evaluation questionnaires. Subchapters also focused on participants' thoughts and feelings that popped up during the interview sessions. While experiencing 360° music videos, along with the participants' emotional reactions the findings also covered pragmatic and hedonic qualities in both contexts of computer monitor and VR goggles.

4.1 Music Videos UX Comparison

The one-way within-subject ANOVA was conducted to compare the viewers' User Experiences among the four different versions of multicamera 360° music videos both in computer monitor and VR goggles. In one-way ANOVA analysis, the independent variable was categorised into four levels (Four different version of videos). The 'α' (significance level) was chosen as 0.05. When the significance value (p-value) is greater than 0.05, one can determine that no statistically significant difference found between the four different version of videos and if significance value (p-value) is less than 0.05, then one can determine that there is a statistically significant difference among the videos' user experiences. The researcher also analysed the sum of squares to represent the differences between individual observation and the total mean.

In Table 3 for computer monitor condition, among the four different version of videos, no significant difference observed on participants' pleasantness rating and overall video rating. Also, no significant difference noticed in rating on felling of being present and active exploration ability on the video content, since the Significance value (p) was higher than 0.05.

Significant difference spotted on participant noticing the cameras changes ($F(3,76) = 7.69$, $p = .00$), $p<0.05$.

Significant difference spotted in participants' concentration losing rating among the videos ($F(3,76) = 9.40$, $p = .00$), $p<0.05$.

Significant difference is also spotted in role of camera changes for video flow enhancing ($F(3,76) = 9.29$, $p = .00$), $p<0.05$.

Table 3. *ANOVA test result for computer monitor condition.*

		Sum of squares	df	Mean Square	F	Sig.
Pleasantness rating in computer Monitor	Between Groups	2.838	3	.946	.411	.746
	Within Groups	175.050	76	2.303		
	Total	177.888	79			
Overall video rating in computer monitor	Between Groups	4.638	3	1.546	.968	.412
	Within Groups	121.350	76	1.597		
	Total	125.988	79			
Noticing the camera changes in computer Monitor	Between Groups	3.250	3	1.083	7.695	.000
	Within Groups	10.700	76	.141		
	Total	13.950	79			
Concentration losing rating in computer Monitor	Between Groups	4.438	3	1.479	9.407	.000
	Within Groups	11.950	76	.157		
	Total	16.388	79			
Role of camera changes for video flow enhancing in computer Monitor	Between Groups	5.338	3	1.779	9.293	.000
	Within Groups	14.550	76	.191		
	Total	19.888	79			
Feeling of being present in computer Monitor	Between Groups	1.238	3	.413	2.580	.060
	Within Groups	12.150	76	.160		
	Total	13.388	79			
Active exploration ability in computer Monitor	Between Groups	.300	3	.100	.768	.516
	Within Groups	9.900	76	.130		
	Total	10.200	79			

In Table 4 for VR goggles condition, among the four different version of videos, no significant difference observed on participants' pleasantness rating and overall video rating because each time the significance value (p) was higher than 0.05.

Significant difference spotted on participants noticing the camera changes ($F(3,76) = 22.76$, $p = .00$), $p<0.05$.

Significant difference spotted on participants concentration losing rating among the videos ($F(3,76) = 11.56$, $p = .00$), $p<0.05$.

Significant difference noticed in the role of camera changes for enhancing the flow of videos ($F(3,76) = 15.52$, $p = .00$), $p<0.05$.

Significant difference also found in rating of being present ($F(3,76) = 7.69$, $p = .00$), $p<0.05$, and in rating of active exploration on the video content ($F(3,76) = 4.89$, $p = .00$), $p<0.05$.

Table 4. *ANOVA test result for VR goggles condition.*

		Sum of Squares	df	Mean Square	F	Sig.
Pleasantness rating in VR Goggles	Between Groups	10.600	3	3.533	1.531	.213
	Within Groups	175.400	76	2.308		
	Total	186.000	79			
Overall video rating in VR Goggles	Between Groups	8.938	3	2.979	1.863	.143
	Within Groups	121.550	76	1.599		
	Total	130.487	79			
Noticing the camera changes in VR Goggles	Between Groups	7.100	3	2.367	22.768	.000
	Within Groups	7.900	76	.104		
	Total	15.000	79			
Concentration losing rating in VR Goggles	Between Groups	4.700	3	1.567	11.560	.000
	Within Groups	10.300	76	.136		
	Total	15.000	79			
Role of camera changes for video flow enhancing in VR Goggles	Between Groups	7.600	3	2.533	15.527	.000
	Within Groups	12.400	76	.163		
	Total	20.000	79			
Feeling of being present in VR Goggles	Between Groups	3.250	3	1.083	7.695	.000
	Within Groups	10.700	76	.141		
	Total	13.950	79			
Active exploration ability in VR Goggles	Between Groups	1.538	3	.513	4.899	.004
	Within Groups	7.950	76	.105		
	Total	9.488	79			

4.2 Users' Music Video Evaluation

The user evaluation questionnaires mainly focused on the participants' experiences after watching the videos. This study analysed the user experiences for all the four different versions of music videos both in computer monitor and VR goggles. Mean and standard deviation analysis with boxplot and bar graphic representation were used to visualise the user experience comparison among the four music videos.

Box plots are used to visualise the overall patterns of response with the range and other characteristics of responses for a group of participants. The middle box demonstrates the inter-quartile range or middle of scores for the group. The middle horizontal lines which divide the boxes into two parts refer the medians. The upper and lower whiskers represent scores outside the middle [72].

Figure 7 shows in computer monitor condition, participants' response for 'How pleasant was the music? [Appendix C: Post Test Evaluation questionnaire]' between very pleasant – very unpleasant where Popeda A was with a mean of 4.15 and standard deviation, SD = 1.75. Popeda B was with a mean of 4.50 and standard deviation, SD = 1.35. Popeda C was with a mean of 4.55 and standard deviation, SD = 1.46. Lastly, Popeda D was with a mean of 4.15 and standard deviation, SD=1.46. Therefore, on an average, the test participants found the Popeda as more pleasant than the other music videos.

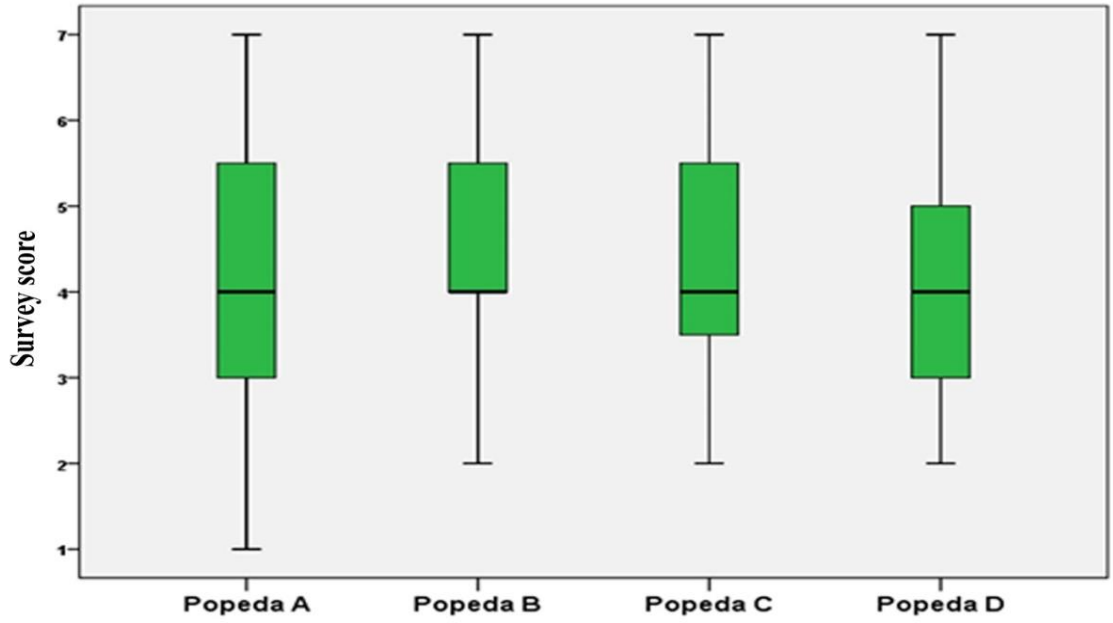

Figure 7. *Boxplot representation of participants' pleasantness rating in computer monitor condition.*

Figure 8 shows in VR goggles condition, participants' response for 'How pleasant was the music? [Appendix C: Post Test Evaluation questionnaire]' between very pleasant – very unpleasant where Popeda A was with a mean of 4.25 and standard deviation, SD = 1.65. Popeda B was with a mean of 4.75 and standard deviation, SD = 1.41. Popeda C was with a mean of 4.95 and standard deviation, SD = 1.23. Lastly, Popeda D was with a mean of 4.05 and standard deviation, SD=1.73. Therefore, on an average, the test participants found the Popeda C more pleasant. Also, the other videos scored quite closer. As VR itself is an immersive technology, it can be a reason behind participants' marking all the videos quite nearer.

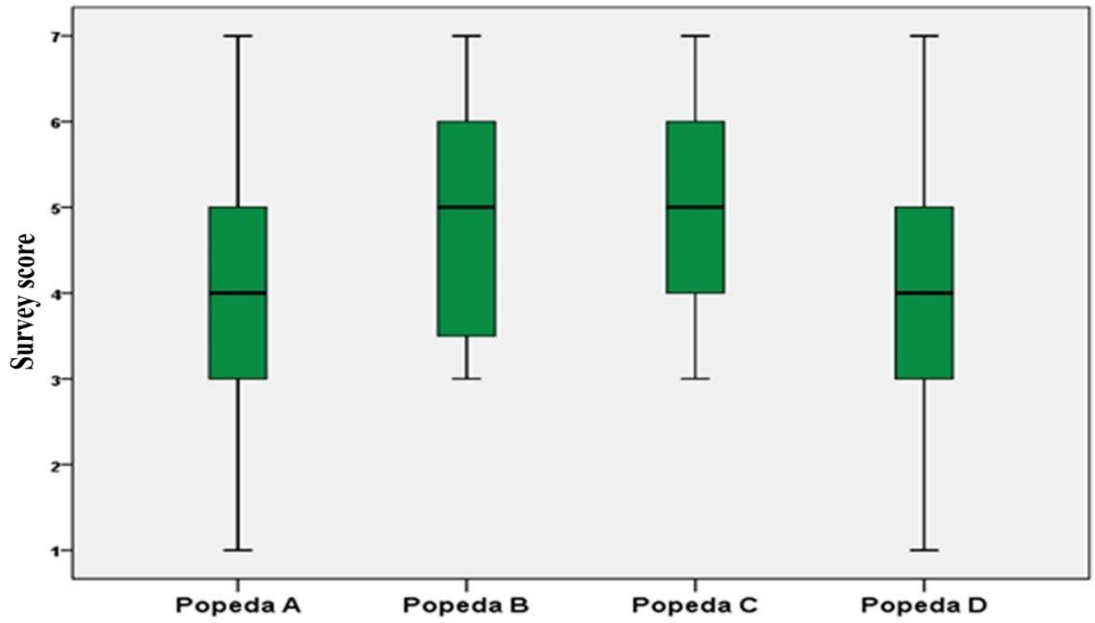

Figure 8. *Boxplot representation of participants' pleasantness rating in VR goggles condition.*

Figure 9 shows in computer monitor condition, participants' response for 'How do you rate the video? [Appendix C: Post Test Evaluation questionnaire]' between very good – very bad where Popeda A was with a mean of 3.85 and standard deviation, SD = 1.34. Popeda B was with a mean of 4.30 and standard deviation, SD = 1.12. Popeda C was with a mean of 4.40 and standard deviation, SD = 1.18. Lastly, Popeda D was with a mean of 3.90 and standard deviation, SD=1.37. Therefore, on an average, the test participants rated the Popeda C and then Popeda B as good while the Popeda D stands with a lower mean.

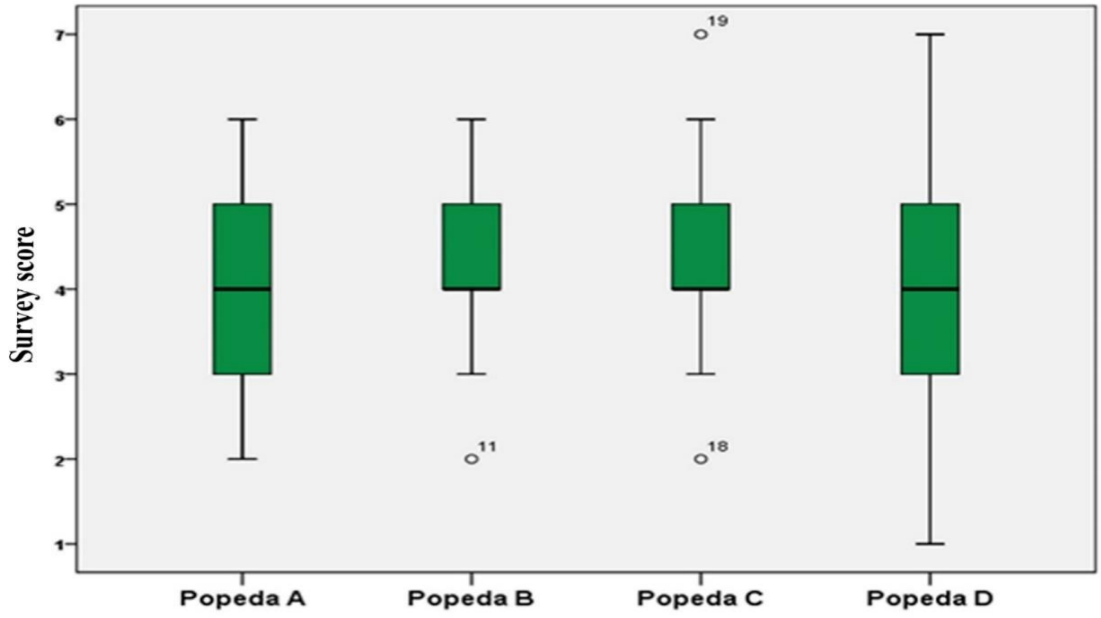

Figure 9. *Boxplot representation of participants' overall video rating in computer monitor condition.*

Figure 10 shows in VR goggles condition, participants' response for 'How do you rate the video? [Appendix C: Post Test Evaluation questionnaire]' between very good – very bad where Popeda A was with a mean of 4.20 and standard deviation, SD = 1.43. Popeda B was with a mean of 4.75 and standard deviation, SD = 1.25. Popeda C was with a mean of 4.60 and Standard deviation, SD = 0.82. Lastly, Popeda D was with a mean of 3.90 and standard deviation, SD=1.44. Therefore, on an average, the test participants rated the Popeda B as good and then Popeda C. In this case, Popeda D also stands with a lower mean.

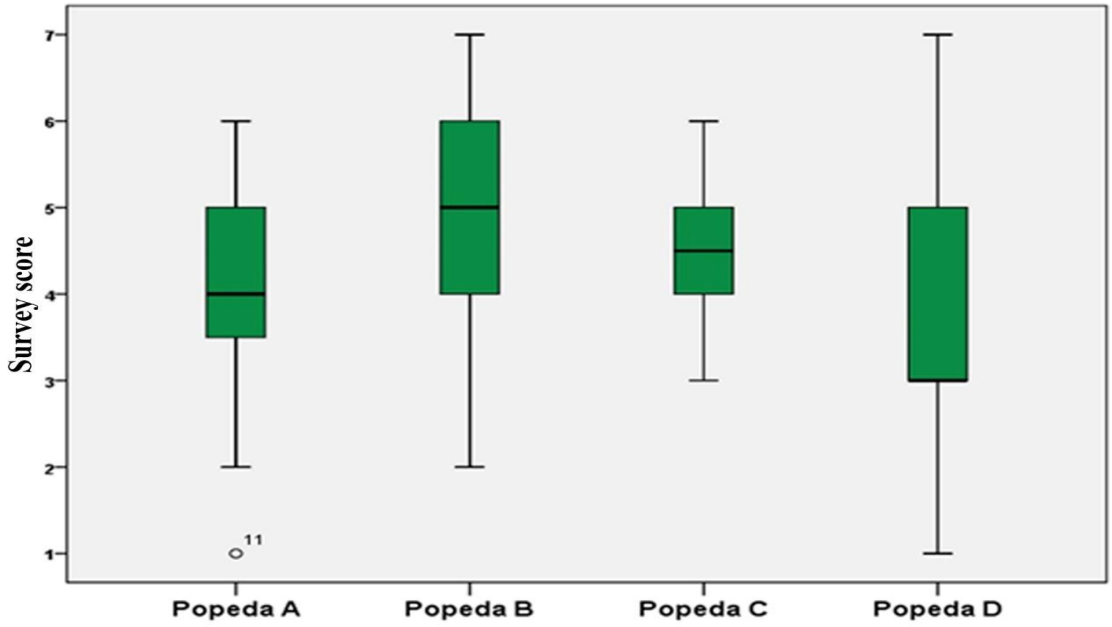

Figure 10. *Boxplot representation of participants' overall video rating in VR goggles condition.*

Figure 11 shows in computer monitor, 55 % of the test participants reported that in Popeda D the camera changed too frequently while in Popeda C and B it was by 20% and 15% respectively. On the other hand, in VR 75% participants mentioned that the camera changes too frequently in Popeda D while in Popeda C it was mentioned only by 20% of the test participants.

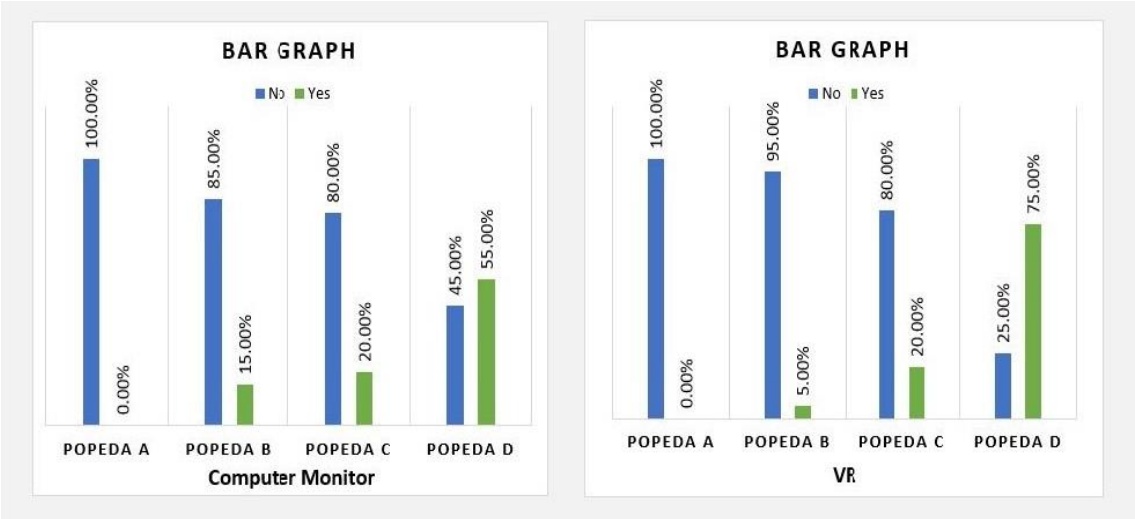

Figure 11. *Bar graphs of participants' answer to the question "Did the cameras change too frequently ?"*

Figure 12 shows, for both computer monitor and VR goggles 65% of the participants reported that they had lost their concentration because of camera changes in Popeda D. 30% of the test participants reported that they had lost their concentration because of camera changes for Popeda C in computer monitor condition. While for VR goggles it was relatively low. Only 15% of the test participants had lost their concentration because of camera changes for Popeda C in VR goggles. For both computer monitor and VR goggles, 20% of the test participants reported they had lost their concentration because of camera changes in Popeda B.

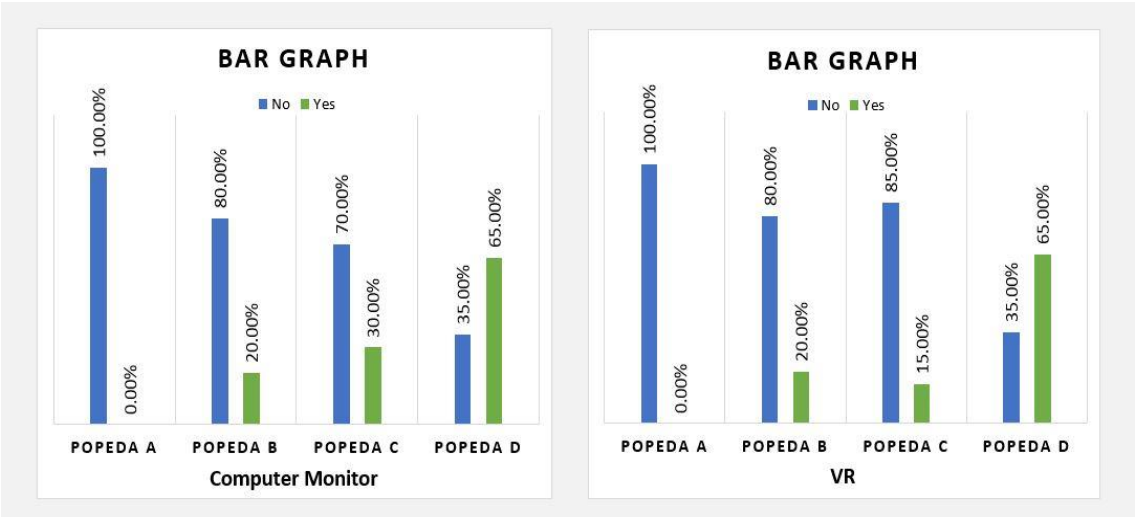

Figure 12. *Bar graphs of participants' answer to the question "Did you lose your concentration because of camera changes?".*

Figure 13 shows, for computer monitor 75% of test participants reported that camera changes of Popeda C enhanced the flow of the video. While for Popeda B, it was reported by 70% of the test participants and 60% for Popeda D. In VR goggles condi-

tion 80% of the test participants reported camera changes of Popeda B enhanced the flow of the video. While for Popeda C, and Popeda D accordingly it was reported by 70% and 50% of the test participants.

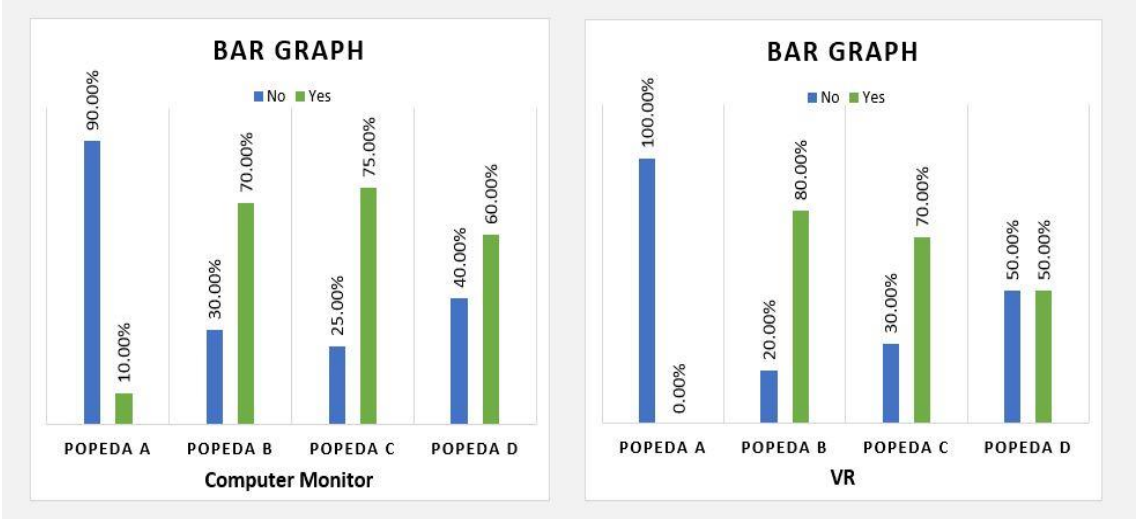

Figure 13. *Bar graphs of participants' answer to the question "Did the camera changes enhance the flow of video?".*

Figure 14 shows, for computer monitor 80% of the test participants reported Popeda B and Popeda C camera changes did not reduce the feeling of being present in the environment. While 60% of the test participants reported same for Popeda D. In VR goggles, 85% of the participants reported Popeda B camera changes did not reduce the feeling of being present in the environment while the similar response was given by 80% of the participants for Popeda C and 45% for Popeda D.

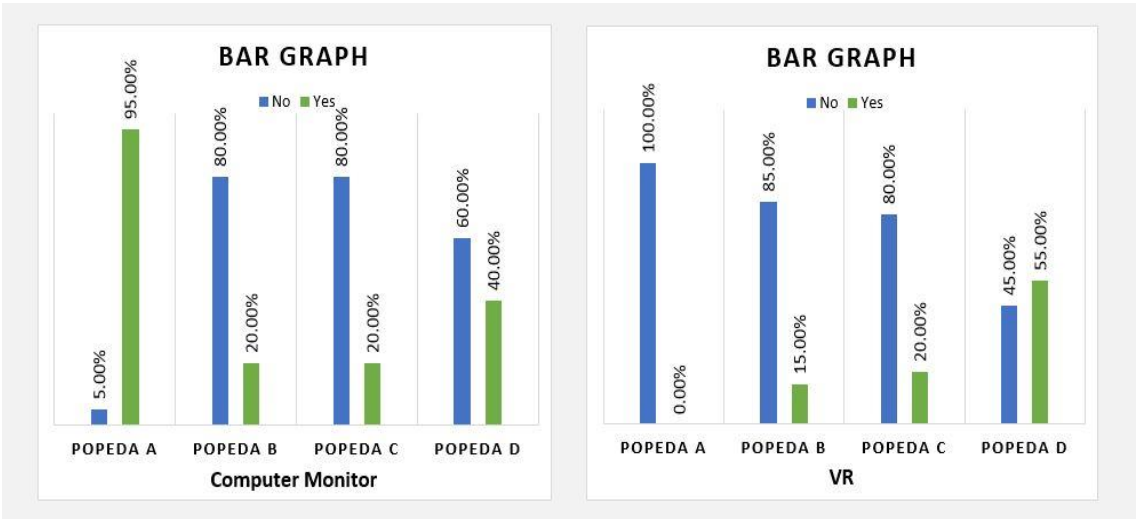

Figure 14. *Bar graphs of participants' answer to the question "Did the camera changes reduce the feeling of being present in the environment?"*

Figure 15 shows, for computer monitor 95% of the test participants reported that, they were actively able to explore the video environment for Popeda C. 85% of the test participants were actively able to explore the video environment for Popeda B. Correspondingly, 80% of the test participants reported that, they were actively able to explore the video environment for both Popeda A and Popeda D.

Figure 15 also shows, for VR goggles 100% test participants reported that, they were actively able to explore the video environment both for Popeda B and Popeda C. While for Popeda A and Popeda D correspondingly 70% and 75% of the test participants were able to do active exploration in the video environment.

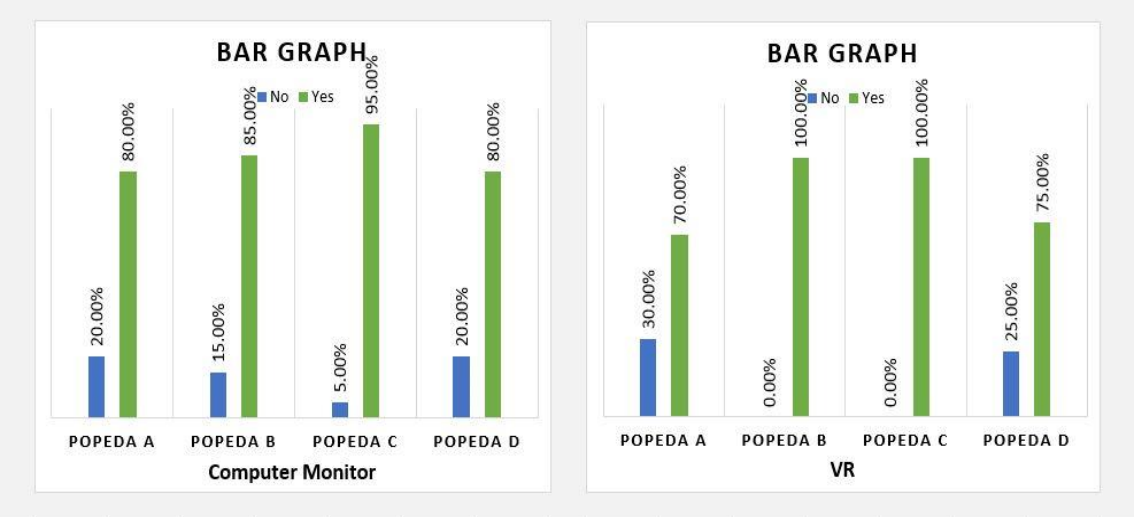

Figure 15. *Bar graphs of participants' answer to the question "Were you able to actively explore or search the environment?"*

4.3 Users' Best Video Ranking

During the interview session, participants were also asked to rank the videos from the best video to fourth best based on their judgment. The cross-tabulation analysis was used to compare and visualise the participants' response.

Table 5 and figure 16 shows that, 45% of test participants reported Popeda C as the best video for both in computer monitor and VR goggles. Popeda C got higher ratings also from the result of the overall rating and pleasantness rating (Figure 7, Figure 8 and Figure 9). 25% and 30% of the participants mentioned Popeda B as best video respectively for computer monitor and VR goggles.

Table 5. *Cross-tabulation analysis for the best video.*

			Computer Monitor	VR Goggles	Total
Best Video	**Popeda A**	Count	1	3	4
		% within VIDEOS	5.0%	15.0%	10.0%
	Popeda B	Count	5	6	11
		% within VIDEOS	25.0%	30.0%	27.5%
	Popeda C	Count	9	9	18
		% within VIDEOS	45.0%	45.0%	45.0%
	Popeda D	Count	5	2	7
		% within VIDEOS	25.0%	10.0%	17.5%
Total		Count	20	20	40
		% within VIDEOS	100.0%	100.0%	100.0%

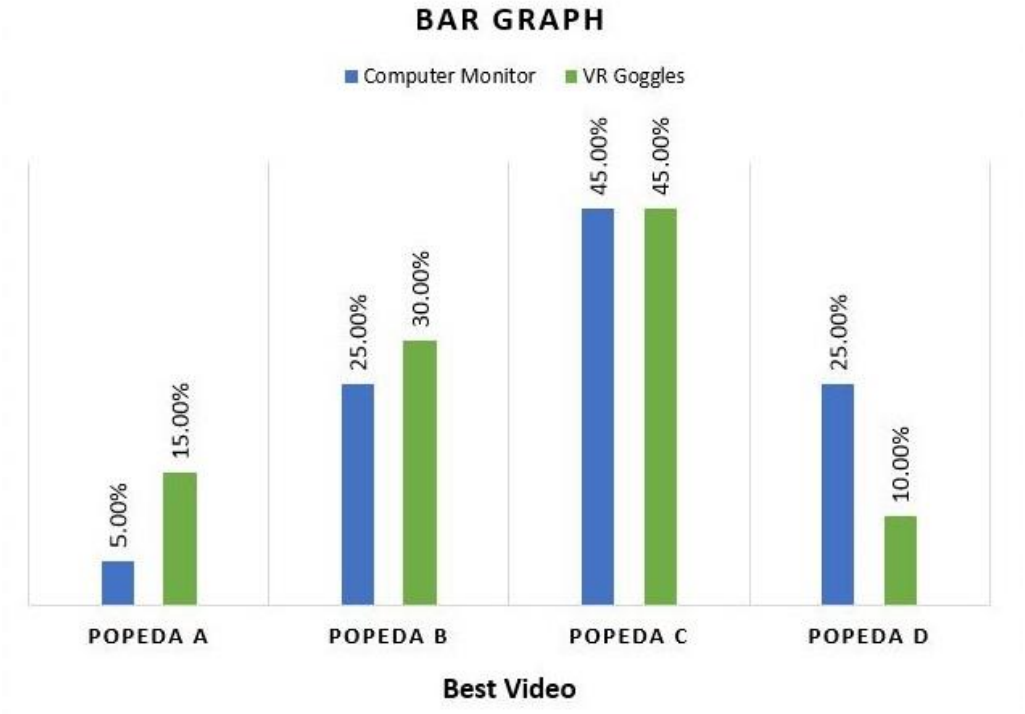

Figure 16. *Bar graph of participants' rating for the best video.*

Table 6 and figure 17 shows that Popeda B was marked as the second-best video by 45% of the participants for computer monitor and 40% for the VR goggles. Although Popeda C was mentioned by 35% of the participants for computer monitor and 20% for VR goggles.

Table 6. *Cross-tabulation analysis for the 2nd best video.*

			Computer Monitor	VR Goggles	Total
2nd Best	**Popeda A**	Count	1	4	5
		% within VIDEOS	5.0%	20.0%	12.5%
	Popeda B	Count	9	8	17
		% within VIDEOS	45.0%	40.0%	42.5%
	Popeda C	Count	7	4	11
		% within VIDEOS	35.0%	20.0%	27.5%
	Popeda D	Count	3	4	7
		% within VIDEOS	15.0%	20.0%	17.5%
Total		Count	20	20	40
		% within VIDEOS	100.0%	100.0%	100.0%

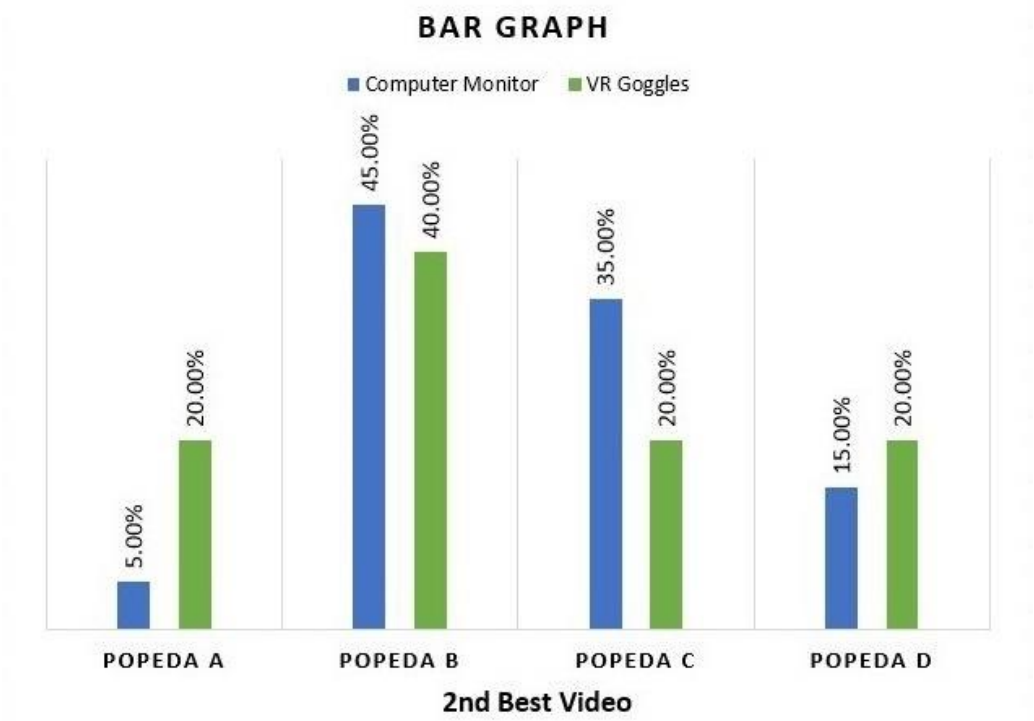

Figure 17. *Bar graph of participants' rating for the 2nd best video.*

Table 7 and Figure 18 shows that 30% of test participants reported Popeda B as the third best video for both in computer monitor and VR goggles. While Popeda C was reported by 15% and 35% respectively for computer monitor and VR goggles. Although

as third best video 35% participants reported Popeda A for computer monitor and 25% reported Popeda D for VR goggles.

Table 7. *Cross-tabulation analysis for the 3rd best video.*

			Computer Monitor	VR Goggles	Total
3rd Best	**Popeda A**	Count	7	2	9
		% within VIDEOS	35.0%	10.0%	22.5%
	Popeda B	Count	6	6	12
		% within VIDEOS	30.0%	30.0%	30.0%
	Popeda C	Count	3	7	10
		% within VIDEOS	15.0%	35.0%	25.0%
	Popeda D	Count	4	5	9
		% within VIDEOS	20.0%	25.0%	22.5%
Total		Count	20	20	40
		% within VIDEOS	100.0%	100.0%	100.0%

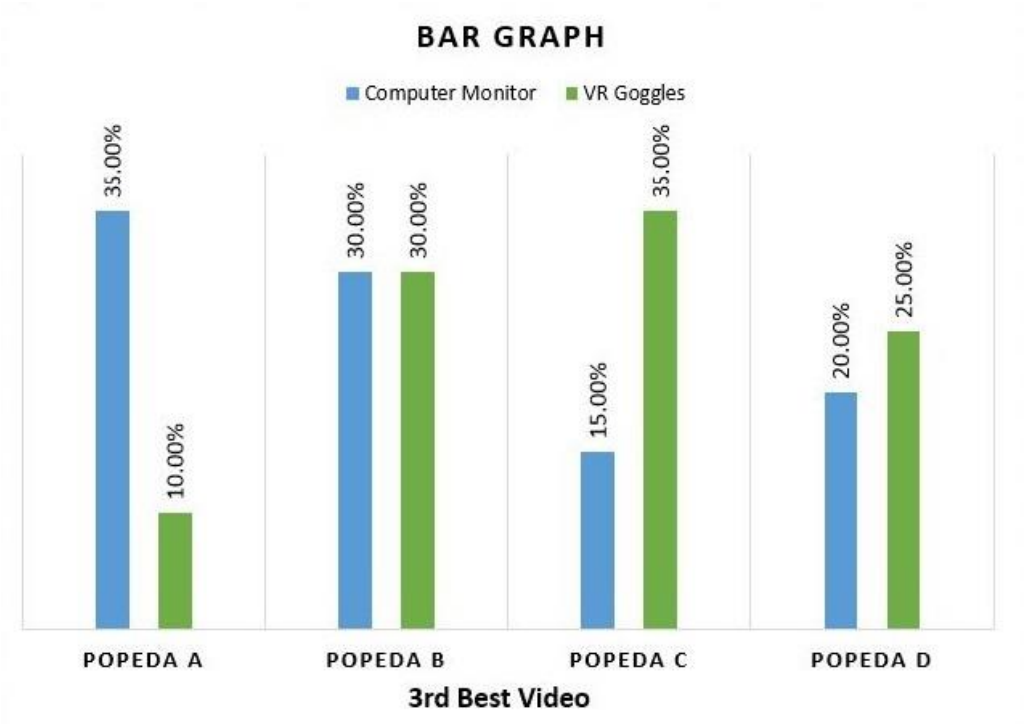

Figure 18. *Bar graph of participants' rating for the 3rd best video.*

Table 8 and Figure 19 shows that 55% of participants reported Popeda A as the fourth best video for both in computer monitor and VR goggles while Popeda D was reported by 40% and 45% respectively for computer monitor and VR goggles.

Table 8. *Cross-tabulation analysis for the 4th best video.*

			Computer monitor	VR Goggles	Total
4th Best	**Popeda A**	Count	11	11	22
		% within VIDEOS	55.0%	55.0%	55.0%
	Popeda C	Count	1	0	1
		% within VIDEOS	5.0%	0.0%	2.5%
	Popeda D	Count	8	9	17
		% within VIDEOS	40.0%	45.0%	42.5%
Total		Count	20	20	40
		% within VIDEOS	100.0%	100.0%	100.0%

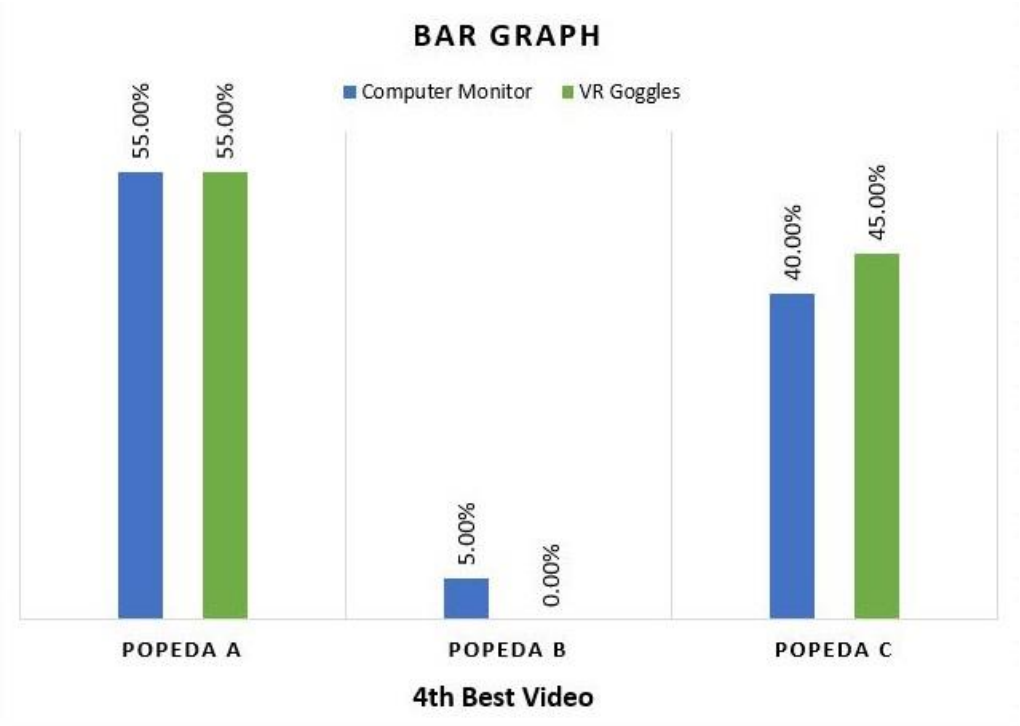

Figure 19. *Bar graph of participants' rating for the 4th best video.*

4.4 How Users' Enjoyed the Videos

30% of the test participants reported that they enjoyed the 360° music videos in computer monitor, and the videos were found as interesting, pleasant and enjoyable. One of the participants mentioned that he felt "*Music has no language*" another participant mentioned that "*Watching 360° videos from monitor seems useful for me since I do not want to move or turn around*". 35% test participants reported that, they could not enjoy the videos well. They mentioned that framerate and video quality seemed bad, the interaction was too slow also annoying while moving with the mouse for computer monitor. Another participant mentioned that "*The videos were not too interesting like traditional stage performance video*". This participant also mentioned that "*Videos did not match with my expectations and discovered as less immersive in computer monitor though it was 3D*".

On the other hand, 85% of the test participants reported that 360° music videos were more enjoying, exciting and brought a more realistic visual experience in VR goggles than the computer monitor. Participants mentioned that the video quality appears better in VR goggles and brings better opportunity to consume the video content through the head-mounted device. While using the head-mounted device viewers can easily look in any direction only by moving the head. One of the participants mentioned that "*I just felt being in the concert and closer to the band members*". Another participant mentioned that "*The visual experience in VR goggles was highly realistic and I think if people get a chance to enjoy the 360° records of concerts or live events that they missed, they will never miss it*". Some of the participants mentioned that VR goggles felt burdensome to them and stage light disturbed their visual experiences.

4.5 Video Users' Liked the Most

During the interview session, 60% participants liked Popeda C and reported as best both for computer monitor and VR goggles condition. Participants reported that the cutting rate of Popeda C was not changed too fast nor too slow. Viewers did not require to move the mouse many times because the video itself showing different angles and positions for the users. Participants also mentioned that the duration of each scene for Popeda C was well enough and convenient to explore. One of them stated that "*Popeda C was pleasant and immersive because it gives proper time to explore and the changes came when I felt a need*". Another participant reported that "*C was easy to perceive from different positions, and the camera changes match with my expectations*".

On the other hand, 35% of the test participants reported Popeda D as worst because viewers did not get enough time to explore. It was also found as trying to focus because after every cut the participant had to look around to familiarise with the new place that lost viewers concentration. One participant mentioned that "*Popeda D was more like TV video because the camera changed too frequently*". Another participant mentioned that

"*I was so uncomfortable and tensed while watching Popeda D about when the camera is changing again*".

Though three participants enjoyed Popeda B for computer monitor and four for VR goggles because they felt the cuts were in a static way which gave them more time to explore the video environment. For VR goggles condition one participant stated that "*I felt I am present at the concert and Popeda B gave me enough time to enjoy everything happening there*". Though two of the participants enjoyed Popeda D since they preferred quick camera changing. For VR goggles one of the participants mentioned that "*It was to fun to get all the viewpoint quickly*".

4.6 The Feeling of Being Bored

For computer monitor 20% of the test participants and for VR goggles 35% test participants reported that they did not face any boredom for any of the videos. For computer monitor one participant mentioned that "*I did not get bored, because the light and crowd all were interesting*". For VR goggles one participant mentioned that "*It was too immersive and felt like being present at the concert*", another participant mentioned that "*360° video exploration was exciting and interesting*".

On the other hand, 55% of the test participants for computer monitor and 60% for VR goggles reported that they felt bored while watching Popeda A. Because it was static, showed from one perspective and stack at one place. It was also revealed that stacking at one place narrowed the users' viewpoint. For computer monitor condition one participant reported that "*I felt bore while moving with the mouse cursor*".

Repetition of the same video was another reason for boredom mentioned by three participants in computer monitor condition and by two participants in VR goggles condition.

4.7 The Feeling of Being Lost

Among the test participants, 15% for computer monitor and 35% for VR goggles mentioned that they did not feel lost at any point. 60% participants for computer monitor and 35% participants for VR goggles, reported that they felt lost while watching Popeda D. While exploring Popeda D, few immediate cuts took viewers to another point that interfered their experience. Popeda D was also reported as hard to explore within the video environment because of faster camera change. One participant mentioned that "*I was exploring the crowd and a sudden cut changed my perspective and took me back to the stage heading towards the wall*". Another participant reported that "*A sudden camera change teleported me to another position then I had to use some time to adopt with the environment at that time again the camera changed to anoth-*

er position, it was annoying". To avoid the situation participant recommended that "*The camera changing should be in a way that the actual perspective does not change*".

4.8 The Most Liked Test Condition

95% of the test participants mentioned that watching 360° videos in VR goggles is more immersive and bring realistic experience since the head-mounted display gives an opportunity to look around only by moving the head. One participant mentioned that "*While watching from VR goggles, it appears like I am in the concert and a part of the band*". Another participant mentioned that "*VR experience was more realistic, it gave me the opportunity to explore anywhere within the video and to get the whole viewpoint, which also helped me to recognise the place where the concert held*". Though one participant preferred 360° video in computer monitor since the participant usually watches 360° videos from an embodied player of Facebook and YouTube.

4.9 Timing and Type of Cuts

In computer monitor condition 80% of the test participants reported Popeda C has the right balance for timing and type of camera changing and found as suitable for watching. They reported that the timing and type of camera change were immaculate because it did not require too many mouse movements and the experience match with the real concert where the audience does not have enough opportunity to move from one place to another so many times. Though one of the participants reported that "*Camera changing frequency was not always the same, during the last two minutes frequency appears inconsistent to me*".

35% of the test participants mentioned that they felt immerse and interactive while the cut was based on the music, performance, concept or theme because it covers all the aspects of the concert. One of the participants mentioned that "*The cameras were focusing to the vocalist, guitarist, keyboardist while they were playing accordingly, and it made him feel like a part of the band*". 20% participants reported Popeda D as distracting and get negative experience because the cutting rate was too fast to explore, and the cuts did not match with the music and performance. One participant mentioned that "*Cuts were happening a bit after the player started playing like I heard the music first and then the cut took me to that player*". Participant also mentioned that "*I prefer vision first and then the music*".

On the other hand, only 15% of the test participants preferred the cutting rate of Popeda D because of its high cutting rate. 20% of the participants mentioned that using screen fading technique while switching from one camera to another made the scenario easily adaptable because fading gives some moment to adjust with new position or viewpoint. One participant reported the cutting rate of Popeda B as impressive because it gives enough time to explore.

On the other hand, For VR goggles condition 35% participants reported the cutting rate of Popeda C meets their expectations, it was equitable not too fast nor too slow. One of the participants mentioned that "*Camera changed just as I liked*". On the other hand, 60% of test participants reported that the cutting rate of Popeda D was fast. One of the participants reported that "*In Popeda D, the camera changed several times, and I felt motion sickness, though I had never face it before*". Another participant mentioned, "*Popeda B was suitable to explore as it gave enough time to explore all the viewpoints including the audience viewpoint and the band members on stage*".

Also, in VR goggles 35% of the participants felt immerse and preferred camera changing based on the music, performance, concept or theme because it covers all the aspects of the concert. One participant mentioned that "*It feels amazing when the band members playing the instruments and camera focused on them*". Another participant mentioned that "*I felt more immerse when got a viewing position from the stage, it made me feel like a part of the band*".

Participants also preferred screen fading technique in VR goggles condition because while switching from one camera to another it was easy to adopt. However, two participants reported that they challenged some jump cuts while exploring the videos. One of them mentioned, "*I was exploring the stage, and suddenly it changed my perspective, then I identified myself facing at the back of stage heading towards the wall*". Another participant mentioned that "*I became surprised when suddenly the camera changed from one place to another*".

One participant spelt out about camera positioning; he reported that "*The song has some exciting parts, but the cuts did not flow them. For this reason, the music was unable to build the excitement also reduced my involvement*". Participant also mentioned that "*To build a good experience and engage the viewers more the cuts should be based on the theme or emotions*". One of the test participants reported that "*Editing itself is user experience. Therefore, the editor should build up that experience if the music can make you move the camera can also make you move*". Participants also reported that at some point the camera could be closer to the band members. One of the participants mentioned, "*While the camera was closer to the band, I felt immersed and willing to play the guitar*".

Two of the participants faced issue about the camera positioning, one of them mentioned, "*One camera was placed in the edge of the stage, and I was feeling scared, it feels I am going to fall from the stage*". The other participant mentioned that "*While watching through the camera which was placed in the edge of stage and audience, I felt confused about whether I belong to the band or belong to the crowd*".

5. DISCUSSION

The results of the study came up with several core issues on 360° music videos user experience. For both computer monitor and VR goggles, Popeda C marked as best video and Popeda B marked as second best by the participants while Popeda D was not revealed at any of the ranks. Users felt lost while watching Popeda D because of the higher cutting rate. This higher cutting rate also made the video hard to comprehend. Based on quantitative data, users did not spot any significant difference on the pleasantness of the music and ranked all the four videos quite nearer both for computer monitor and VR goggles. Among the four different versions of 360° videos, the significant difference observed for participants' rating on concentration losing because of camera change and video flow enhancing. For the computer monitor condition, no significant difference found on participants feeling of being present and the ability to active exploration within the video content, but significant difference was observed in VR goggles condition.

Based on qualitative data both for computers monitor and VR goggles, the user gets high-quality experiences while watching Popeda C. While exploring the video content of Popeda C, the right balance of cuts and camera changing type brought pleasant experiences among the viewers. However, some unpleasant experiences were delivered because of a faster cutting rate in Popeda D and the static viewpoint of Popeda A.

In VR goggles, the video appears more enjoying, exciting and brings more realistic visual experiences than the computer monitor. The video quality appears better in VR goggles than computer monitor and brings opportunity to consume the video content through the head-mounted device, since the head-mounted device allows the user to look at any direction by moving the head. The viewers found Popeda A as static as it showed from one perspective only. The staticity delivered some boredom towards viewers experience and narrowed their viewpoint. In some cases, the camera change had limited bond with the audio and the flow of story. The video cutting rate should be based on the concept, theme or story which could make the video more immersive, interactive and can deliver high-quality user experience.

The participants also faced issues because of camera positioning. Positioning a camera at the edge of the stage made participants feel scared. One participant felt that he is going to fall from the stage. The participant gave solution for this that the position should be changed in a way that it does not the actual perspective.

5.1 Findings

To summarise the thesis findings for the user experience of 360° music videos on computer monitor and virtual reality goggles are flowing:

Quality user experience:

Popeda C, i.e., the official YouTube release, delivered high-quality user experiences both for computer monitor and VR goggles. Users found right balance of cutting rate and camera changing type in Popeda C which delivered a pleasing experience. Popeda C camera changing type matched with the viewers' expectations. Also, the length of each shot in Popeda C was well enough and convenient to explore.

Effects of cutting rate:

Exploration within the content of Popeda C was pleasant and enjoyable. The faster cutting rate of Popeda D delivered unpleasant experiences. Popeda D was found as distracting also challenging to focus. The higher cutting rate of Popeda D made the video exploration harder. For Popeda D, viewers were unable to explore the video content properly. Cutting rate of Popeda D did not match with the music and performance. Viewers' felt lost while watching Popeda D because of the higher cutting rate. After every cut in Popeda D, the viewers had to familiarise with the new place that loses their concentration.

Unpleasantness of static view:

Popeda A showed from one perspective and stack at one place. This static viewpoint of Popeda A delivered unpleasant experiences. The static viewpoint made the viewers bored and narrowed their viewpoint. Video interaction remained slow while viewers exploring with the mouse for computer monitor.

Supremacy of VR goggles:

In VR goggles the videos appear more enjoying, exciting and deliver realistic visual experiences than the computer monitor. The video quality appears better in VR goggles than computer monitor. The head-mounted device was found as an effective way of 360° video consuming. While editing the 360° video, the cut should not change the users' actual perspective of view. Viewers' feel immersed and interactive while the cut was based on the music, performance, concept or theme since it covers all the aspects of the concert.

Usefulness of screen fading technique:

Screen fading technique was found as useful while switching from one camera to another. Screen fading technique gives extra time to the viewers for adjusting with the new position which made the scenario easily adaptable.

Jump cut avoiding:

Viewers challenged some jump cuts while exploring the videos. They got surprised when the camera suddenly changed from one place to another. To deliver a high-quality experiences, jump cuts should be avoided. Moreover, the cuts should be based on the content theme or viewers' emotional aspects.

Effects of camera positioning:

Camera positioning also played an important role on 360° video user experiences. Based on the story and theme, the camera could be closer to the instruments and band members.

5.2 Limitations

There were few limitations in this study, as the researcher has used two different model of mobile phones for the VR goggles condition. One is Samsung Galaxy S7 edge, and another is Samsung Galaxy S8 which can affect the test result reliability. For video streaming, though I have used 100 Mbps network connection, small disturbance observed in some cases. All the test participants were selected very carefully, their previous VR and 360° video experience were quite distributed. Some participants' faced problem with VR goggles focus adjustment, but after little guidance, it was resolved. To keep the audio level equal, a 5-meter 3.5 mm auxiliary cable was used both for computer monitor and VR goggles condition. Audio speaker and the volume level was the same for all the subjects and test conditions. Though some participants warped by the cable while it was connected with the head-mounted display, which can have an impact on the user experiences.

5.3 Future Work

Based on the research findings, future work can be done by refining the research goals and adjusting the research strategy. Deeper concentration can be given on 360° music video experience on VR goggles since my research found VR goggles as an exciting and usable media for 360° experiencing. There are also many other aspects of 360° music videos that could be studied, and one focus theme is the use of spatial audio vs. stereo. By the time while writing this thesis, another thesis work is focusing on 'which

audio (spatial or stereo) the users prefer in case of 360° live music videos, also the reasons behind it'.

6. CONCLUSION

The results of this study indicated that the 360° music video Popeda C which was produced through integrating eight pieces of shots (average length- 26s/shot) captured by four 360° camera, delivered high-quality user experiences both for computer monitor and VR goggles. One of the reasons behind delivering high-quality user experience is video cutting rate which was matched with users' mental model. Another reason was the representation of shots. The video was produced by integrating eight pieces of shots where each shot was presented from different angles and positions based on the theme. Also, the segments between the camera changes were well enough and convenient to explore.

On the other hand, the 360° music video Popeda D where the cutting rate was high and average length of the shot was 11s, delivered low-quality user experiences. One of the reasons behind delivering low-quality user experience is the faster cutting rate. Because of the faster cutting rate, the viewers did not get enough observation time for individual segments and faced difficulties on video exploration. Another reason was the mismatch between shots and theme (music and performance).

Users' had lost their concentration while the camera changed too frequently since the frequent camera change made the segments smaller. Users had expended extra time to familiarise themselves with a new position that worked as a reason behind the concentration losing. Users also felt lost while the camera changed very frequently and suddenly.

Single camera video delivered some boredom to a few users. Popeda A, which was produced by a single camera was found as static and boring. Single camera 360° video narrowed the user's viewpoint because it shows only from one perspective and stack at one place within the video content.

Screen fading technique was found as useful while joining the segments or changing from one camera to another. This screen fading technique gives some moment to viewers for adjusting with the new position or the new viewpoint which made the scenario easily adaptable.

The study results also indicated that camera changing and focusing should be based on the theme, concept, performance, or music. This way it is more convenient to cover all the aspects of the video. Every video may have different emotional part, and the cuts or camera changes should be based on that. If the cuts flow the emotional states of the vid-

eo, it can build a good user experience and engage the viewers more. Therefore, the actual perspective should not change while the camera changes and jump cuts need to be avoided to deliver a quality user experience.

Camera placing or positioning also influenced 360° music video user experiences, since every camera represents a viewing position for the viewers, from where they experienced the 360° video. 360° videos were found more realistic and enjoyable in VR goggles since VR gives better visual appearance than the computer monitor. Also, the video quality and resolutions appear better in VR goggles and provide better opportunity to enjoy the video content through the head-mounted display.

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APPENDIX A: CONSENT FORM

CONSENT FORM: USER EXPERIENCE STUDY OF 360° VIDEOS ON COMPUTER MONITOR AND VR GOGGLES**.**

GENERAL: You are invited to participate in the experiment in which we are going to address the user experience on multicamera 360 music videos by using a computer and VR goggles, I determined to investigate how do most users perceive the four different versions of the videos with different cuts and which factors have effect on the way of cuts. At the end, we are going to formulate some guidelines for editing 360 music video pleasing both in Computer Display (YouTube) and VR Goggles.

DESCRIPTION: During the experiment first, you will watch four different versions of music videos with different frequencies of cuts both in computer monitor and VR goggles. After every video, you will be given some questionnaire (Mostly Yes/No) to evaluate the four different versions of music videos. This evaluation mainly focusses on how you perceive the 360 music videos, and which one brings high-quality user experience by using both from computer monitor and VR goggles. This evaluation also focuses on which version of the video bring more pleasantness to the users. After that, a semi-structured interview will be conducted, and we suggest you to Think-a-loud about your instant experience. Before the experiment, you will be given short trials to practice about the procedure.

RISKS AND BENEFITS: This experiment may make you feel some discomfort or headache as you have to watch music videos on computer display then you need to wear VR Goggles and also have to listen music on speaker. You may also cancel your approval to participate in the experiment at any time. Although a movie ticket will be rewarded to each participant, your participation will help us to find out the optimal frequency of cuts in context of 360° videos and the factors that have effect on the way of cuts.

DURATION: Conducting the experiment may take approximately 1 hour.

PARTICIPANT RIGHTS: During the test, we will record all the audio for further analyzation. The materials recorded during the test will be used only for this project purpose. In addition to test team, the supervisors of the project will also have access on the audio and other materials from the test. The recordings will be destroyed after the project is over.

All the data collected during this experiment will be handled anonymously, also will be reported anonymously, and won't be connected to a certain participant. The participation is voluntary, including that you have the right to cancel your approval any time without any consequences.

CONTACT INFORMATION: If you have any questions, concerns or complaints about this experiment, its procedures, risks and benefits, please contact via mail to Mohammad Remans (xxxxx.@xxx.com)

By signing this consent form, I agreed to participate in the experiment and understood all the possible risk factors. I also understood that my participation is voluntary, and I am entitled to refuse to participate or stop at any time without any consequences.

SIGNATURE

_____

PRINTED **NAME**

_____

DATE **AND** **PLACE**

_____

APPENDIX B: BACKGROUND QUESTIONNAIRE

Background Information Form

Participant Number: ……

1. Age: _____
2. Gender: ❍ Female ❍ Male
3. Education (highest finished degree):
   - ❍ Comprehensive or elementary school
   - ❍ College / University degree
   - ❍ High school
   - ❍ Other_____
4. How much have you used Virtual Reality devices?

	1	2	3	4	5	6	7	
Never	❍	❍	❍	❍	❍	❍	❍	Regularly

5. How much have you watched 360° music videos?

	1	2	3	4	5	6	7	
Never	❍	❍	❍	❍	❍	❍	❍	Regularly

6. How often do you watch music videos?

	1	2	3	4	5	6	7	
Never	❍	❍	❍	❍	❍	❍	❍	Regularly

7. How much do you listen to music?

	1	2	3	4	5	6	7	
Never	❍	❍	❍	❍	❍	❍	❍	Regularly

8. Do you play any musical instruments?

❍ Professional musician. ❍ Hobbyist player. ❍ Not at all.

APPENDIX C: POST TEST EVALUATION QUESTIONNAIRE

User evaluation questionnaire:

Q1. How pleasant was the music?

	1	2	3	4	5	6	7	
Very Unpleasant	❍	❍	❍	❍	❍	❍	❍	Very Pleasant

Q2. How do you rate the video?

	1	2	3	4	5	6	7	
Very Bad	❍	❍	❍	❍	❍	❍	❍	Very Good

Q3. Did the cameras change too frequently?

No Yes

Q4. Did you lose your concentration because of camera changes?

No Yes

Q5. Did the camera changes enhance the flow of video?

No Yes

Q6. Did the camera changes reduce the feeling of being present in the environment?

No Yes

Q7. Were you able to actively explore or search the environment?

No Yes

APPENDIX D: USER INTERVIEW QUESTIONNAIRE

Interview Questions: After watching the videos in each condition

Q1. How did you enjoy the videos?

Q2. Which video did you like the most? Please put them in your order of preference. Why did you order them that way?

Q3. Were some of the video boring? Why?

Q4. While watching the videos did you feel lost at any point? Can you explain why that happened?

Q5. How did you feel about the timing and type of camera changes?

Q6. Did you ever feel bored because of few cuts?

Final Question: After both condition

FQ. While watching 360 videos which condition you liked most: Computer or VR goggles? Why?

Preference of order (for Q2):

COMPUTER	**VR:**
1st Best:	1st Best:
2nd Best	2nd Best
3rd Best:	3rd Best:
4th Best:	4th Best:

APPENDIX E: SPSS ANALYSIS (MEAN AND STD. DEVIATION)

Mean and Std. Deviation analysis of Demographic Data

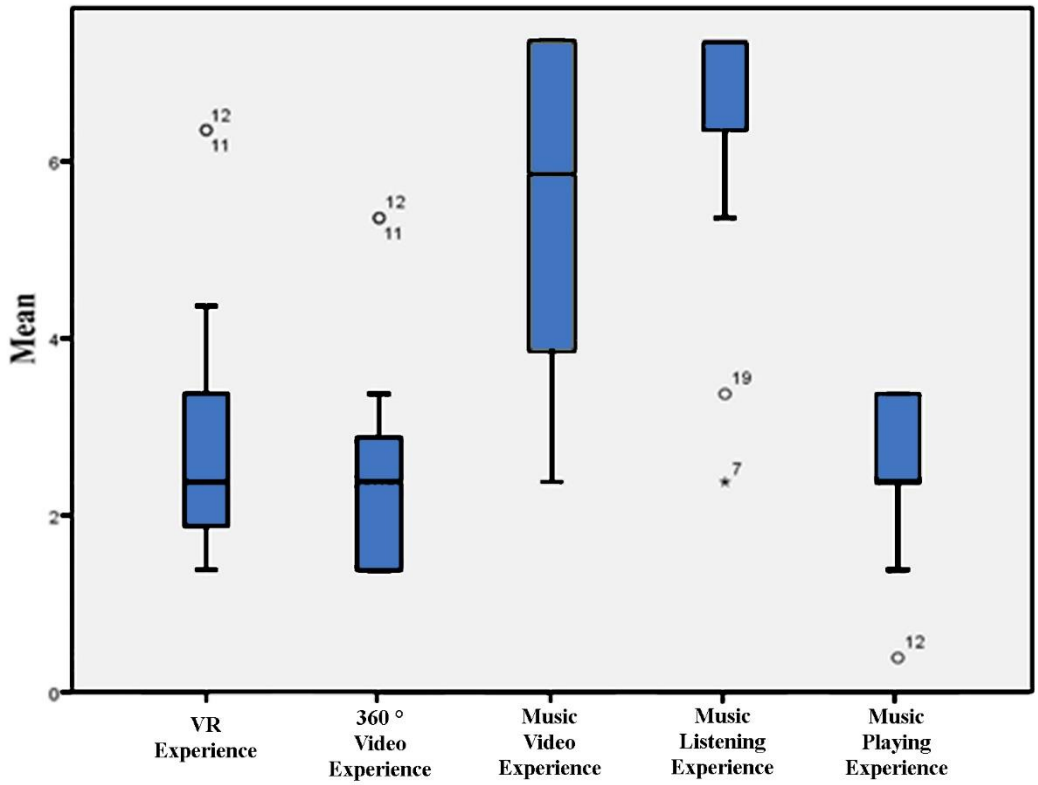
Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Age	20	100.0%	0	0.0%	20	100.0%
Gender	20	100.0%	0	0.0%	20	100.0%
Education	20	100.0%	0	0.0%	20	100.0%
EXPERIENCE_VR	20	100.0%	0	0.0%	20	100.0%
EXPERIENCE_360	20	100.0%	0	0.0%	20	100.0%
EXPERI-ENCE_MUSIC_VIDEO	20	100.0%	0	0.0%	20	100.0%
EXPERI-ENCE_LISTENING_MUSIC	20	100.0%	0	0.0%	20	100.0%
PLAYING_MUSIC	20	100.0%	0	0.0%	20	100.0%

Report

	Age	Gen-der	Educa-tion	EXPERI-ENCE_VR	EXPERI-ENCE_360	EXPERI-ENCE_MUSIC_VIDEO	EXPERI-ENCE_LISTENING_MUSIC	PLAY-ING_MUSIC
Mean	25.05	.80	2.30	2.50	2.10	5.15	6.30	2.25
N	20	20	20	20	20	20	20	20
Std. Devia-tion	4.322	.410	.571	1.469	1.210	1.814	1.418	.786

Box plot of Participants Experience and Familiarities:



Mean and Std. Deviation analysis of Participants' Pleasantness Rating and Overall Rating

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Computer_A_Q1	20	100.0%	0	0.0%	20	100.0%
Computer_B_Q1	20	100.0%	0	0.0%	20	100.0%
Computer_C_Q1	20	100.0%	0	0.0%	20	100.0%
Computer_D_Q1	20	100.0%	0	0.0%	20	100.0%

Report

	Computer_A_Q1	Computer_B_Q1	Computer_C_Q1	Computer_D_Q1
Mean	4.15	4.50	4.55	4.15
N	20	20	20	20
Std. Deviation	1.755	1.357	1.468	1.461

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
Computer_A_Q2	20	100.0%	0	0.0%	20	100.0%
Computer_B_Q2	20	100.0%	0	0.0%	20	100.0%
Computer_C_Q2	20	100.0%	0	0.0%	20	100.0%
Computer_D_Q2	20	100.0%	0	0.0%	20	100.0%

Report

	Computer_A_Q2	Computer_B_Q2	Computer_C_Q2	Computer_D_Q2
Mean	3.85	4.30	4.40	3.90
N	20	20	20	20
Std. Deviation	1.348	1.129	1.188	1.373

Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
VR_A_Q1	20	100.0%	0	0.0%	20	100.0%
VR_B_Q1	20	100.0%	0	0.0%	20	100.0%
VR_C_Q1	20	100.0%	0	0.0%	20	100.0%
VR_D_Q1	20	100.0%	0	0.0%	20	100.0%

Report

	VR_A_Q1	VR_B_Q1	VR_C_Q1	VR_D_Q1
Mean	4.25	4.75	4.95	4.05
N	20	20	20	20
Std. Deviation	1.650	1.410	1.234	1.731

Case Processing Summary

	Cases		
	Included	Excluded	Total

	N	Percent	N	Percent	N	Percent
VR_A_Q2	20	100.0%	0	0.0%	20	100.0%
VR_B_Q2	20	100.0%	0	0.0%	20	100.0%
VR_C_Q2	20	100.0%	0	0.0%	20	100.0%
VR_D_Q2	20	100.0%	0	0.0%	20	100.0%

Report

	VR_A_Q2	VR_B_Q2	VR_C_Q2	VR_D_Q2
Mean	4.20	4.75	4.60	3.90
N	20	20	20	20
Std. Deviation	1.436	1.251	.821	1.447

APPENDIX F: SPSS ANALYSIS (ANOVA TESTING)

Oneway ANOVA Analysis for computer monitor condition

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Computer_Q1	Between Groups	2.838	3	.946	.411	.746
	Within Groups	175.050	76	2.303		
	Total	177.888	79			
Computer_Q2	Between Groups	4.638	3	1.546	.968	.412
	Within Groups	121.350	76	1.597		
	Total	125.988	79			
Computer_Q3	Between Groups	3.250	3	1.083	7.695	.000
	Within Groups	10.700	76	.141		
	Total	13.950	79			
Computer_Q4	Between Groups	4.438	3	1.479	9.407	.000
	Within Groups	11.950	76	.157		
	Total	16.388	79			
Computer_Q5	Between Groups	5.338	3	1.779	9.293	.000
	Within Groups	14.550	76	.191		
	Total	19.888	79			
Computer_Q6	Between Groups	1.238	3	.413	2.580	.060
	Within Groups	12.150	76	.160		
	Total	13.388	79			
Computer_Q7	Between Groups	.300	3	.100	.768	.516
	Within Groups	9.900	76	.130		
	Total	10.200	79			

Oneway ANOVA Analysis for VR goggles condition

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
VR_Q1	Between Groups	10.600	3	3.533	1.531	.213
	Within Groups	175.400	76	2.308		
	Total	186.000	79			

VR_Q2	Between Groups	8.938	3	2.979	1.863	.143
	Within Groups	121.550	76	1.599		
	Total	130.487	79			
VR_Q3	Between Groups	7.100	3	2.367	22.768	.000
	Within Groups	7.900	76	.104		
	Total	15.000	79			
VR_Q4	Between Groups	4.700	3	1.567	11.560	.000
	Within Groups	10.300	76	.136		
	Total	15.000	79			
VR_Q5	Between Groups	7.600	3	2.533	15.527	.000
	Within Groups	12.400	76	.163		
	Total	20.000	79			
VR_Q6	Between Groups	3.250	3	1.083	7.695	.000
	Within Groups	10.700	76	.141		
	Total	13.950	79			
VR_Q7	Between Groups	1.538	3	.513	4.899	.004
	Within Groups	7.950	76	.105		
	Total	9.488	79			

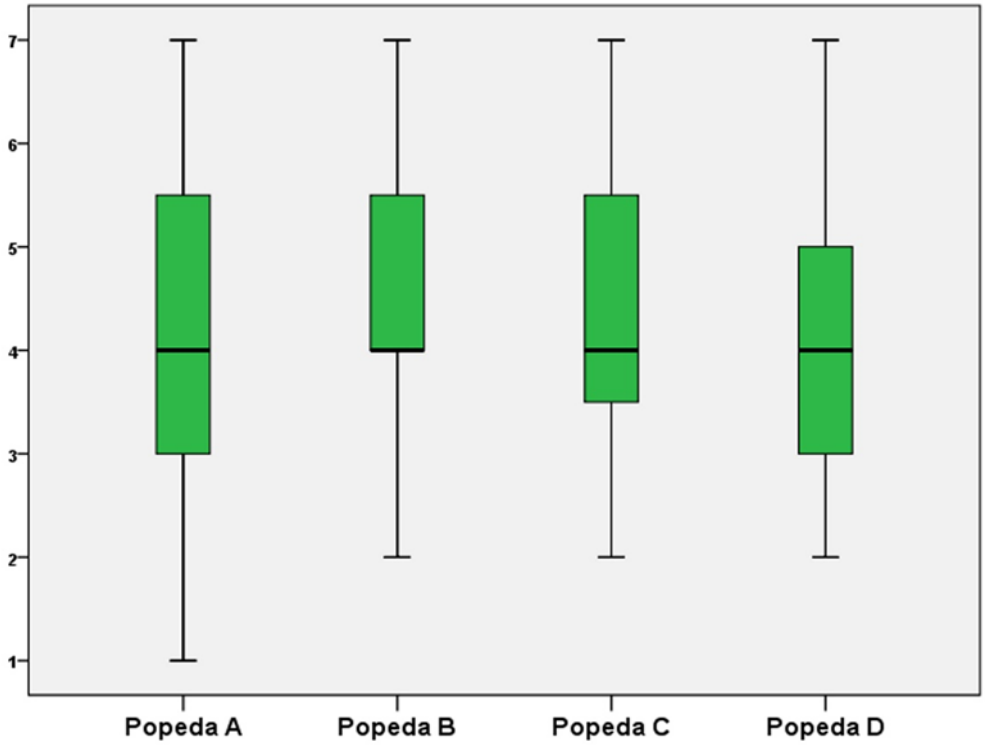
APPENDIX G: SPSS ANALYSIS (CROSS TABULATION)

Cross Tabulation analysis for Computer Monitor condition

Computer * Computer_Q1

Crosstab

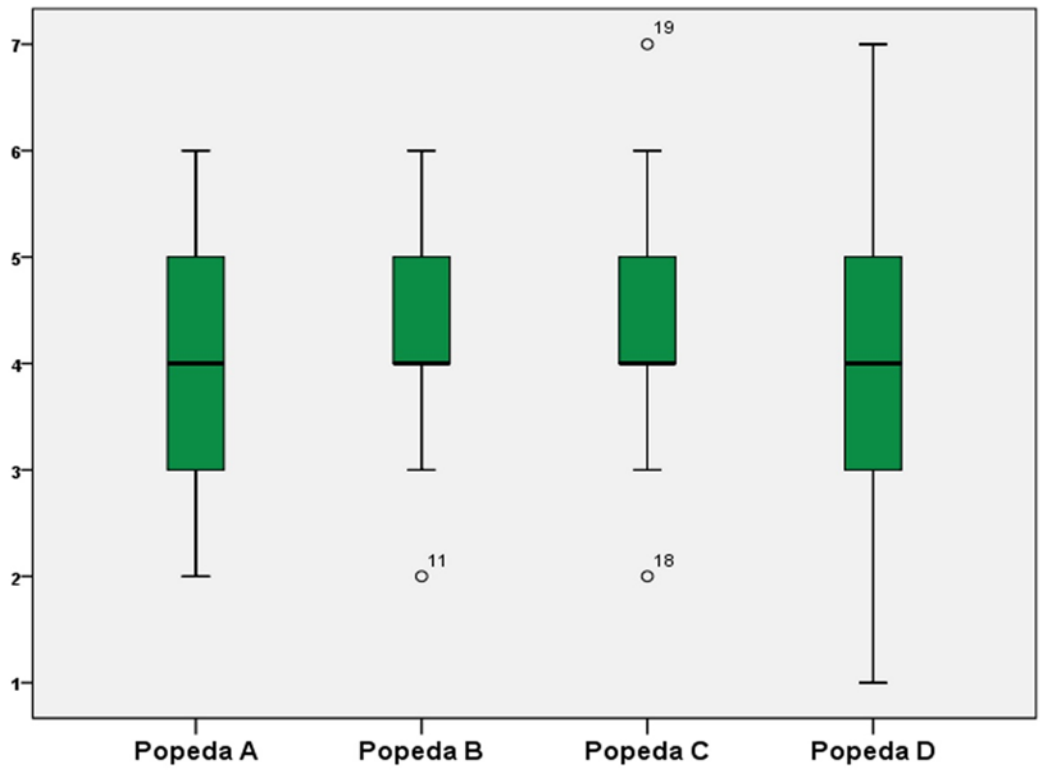
			Computer_Q1							Total
			Very Unpleasant	Moderately Unpleasant	Slightly Unpleasant	Natural	Slightly Pleasant	Moderately Pleasant	Very Pleasant	
Computer	A	Count	1	3	4	3	4	3	2	20
		% within Computer	5.0%	15.0%	20.0%	15.0%	20.0%	15.0%	10.0%	100.0%
	B	Count	0	1	3	8	3	3	2	20
		% within Computer	0.0%	5.0%	15.0%	40.0%	15.0%	15.0%	10.0%	100.0%
	C	Count	0	1	4	6	4	2	3	20
		% within Computer	0.0%	5.0%	20.0%	30.0%	20.0%	10.0%	15.0%	100.0%
	D	Count	0	1	7	6	3	0	3	20
		% within Computer	0.0%	5.0%	35.0%	30.0%	15.0%	0.0%	15.0%	100.0%
Total		Count	1	6	18	23	14	8	10	80
		% within Computer	1.3%	7.5%	22.5%	28.8%	17.5%	10.0%	12.5%	100.0%



Computer * Computer_Q2

Crosstab

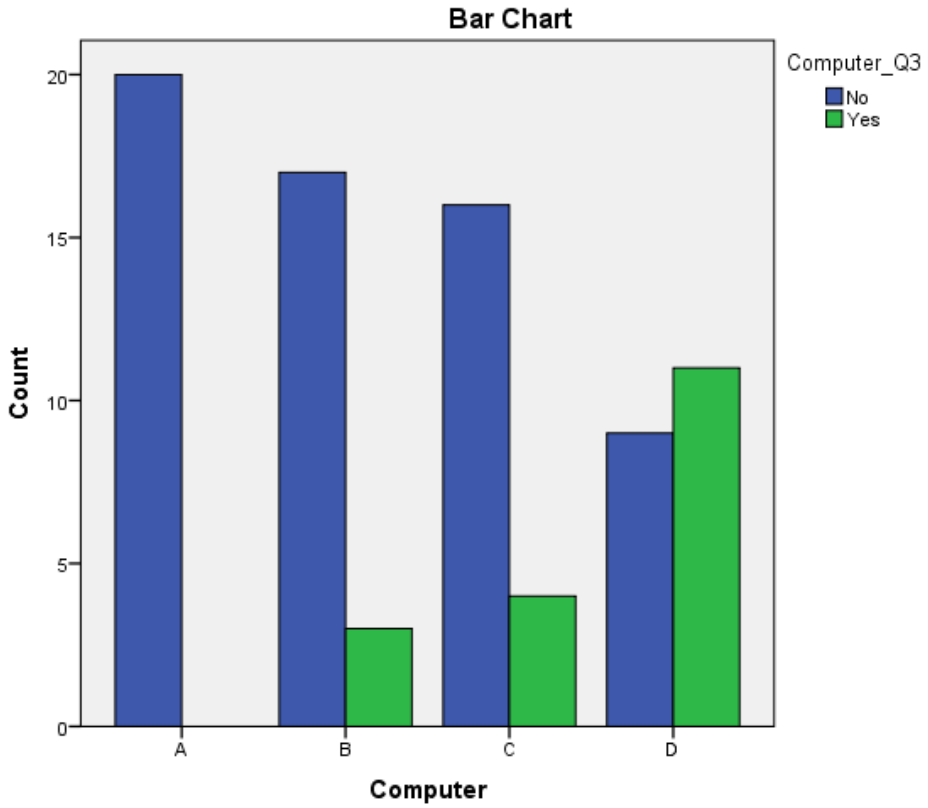
			Computer_Q2							Total
			Very Bad	Moderate-ly Bad	Slightly Bad	Natural	Slightly Good	Moderate-ly Good	Very Good	
Computer	A	Count	0	4	4	6	3	3	0	20
		% within Computer	0.0%	20.0%	20.0%	30.0%	15.0%	15.0%	0.0%	100.0 %
	B	Count	0	1	3	9	3	4	0	20
		% within Computer	0.0%	5.0%	15.0%	45.0%	15.0%	20.0%	0.0%	100.0 %
	C	Count	0	1	3	7	6	2	1	20
		% within Computer	0.0%	5.0%	15.0%	35.0%	30.0%	10.0%	5.0%	100.0 %
	D	Count	1	2	4	6	6	0	1	20
		% within Computer	5.0%	10.0%	20.0%	30.0%	30.0%	0.0%	5.0%	100.0 %
Total		Count	1	8	14	28	18	9	2	80
		% within Computer	1.3%	10.0%	17.5%	35.0%	22.5%	11.3%	2.5%	100.0 %



Computer * Computer_Q3

Crosstab

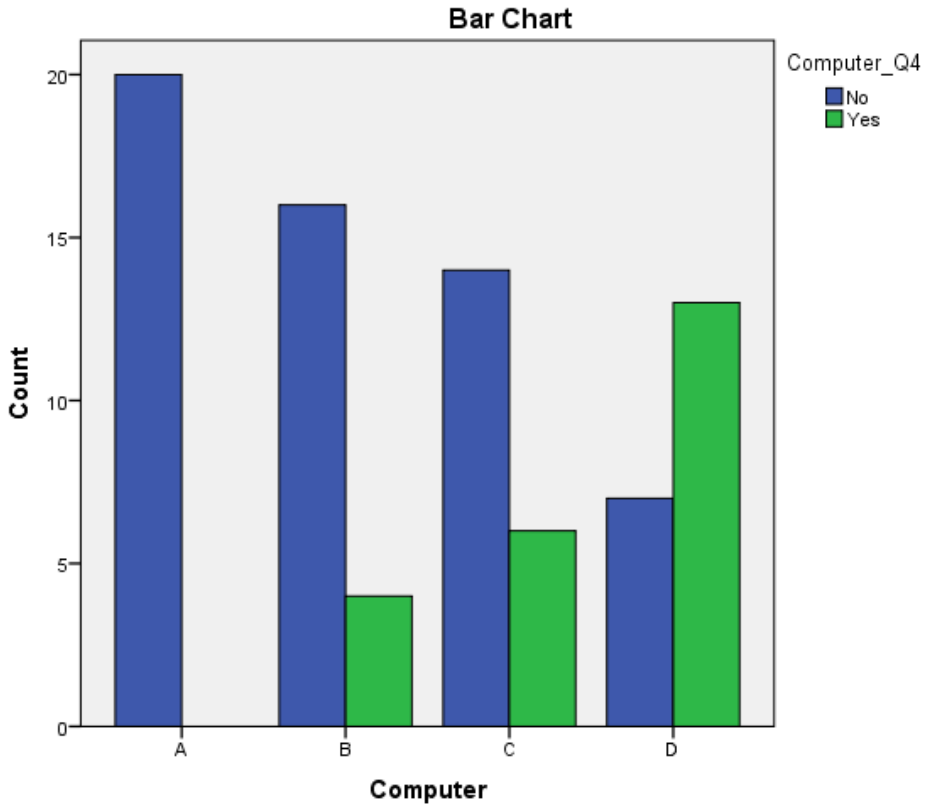
			Computer_Q3		
			No	Yes	Total
Computer	A	Count	20	0	20
		% within Computer	100.0%	0.0%	100.0%
	B	Count	17	3	20
		% within Computer	85.0%	15.0%	100.0%
	C	Count	16	4	20
		% within Computer	80.0%	20.0%	100.0%
	D	Count	9	11	20
		% within Computer	45.0%	55.0%	100.0%
Total		Count	62	18	80
		% within Computer	77.5%	22.5%	100.0%



Computer * Computer_Q4

Crosstab

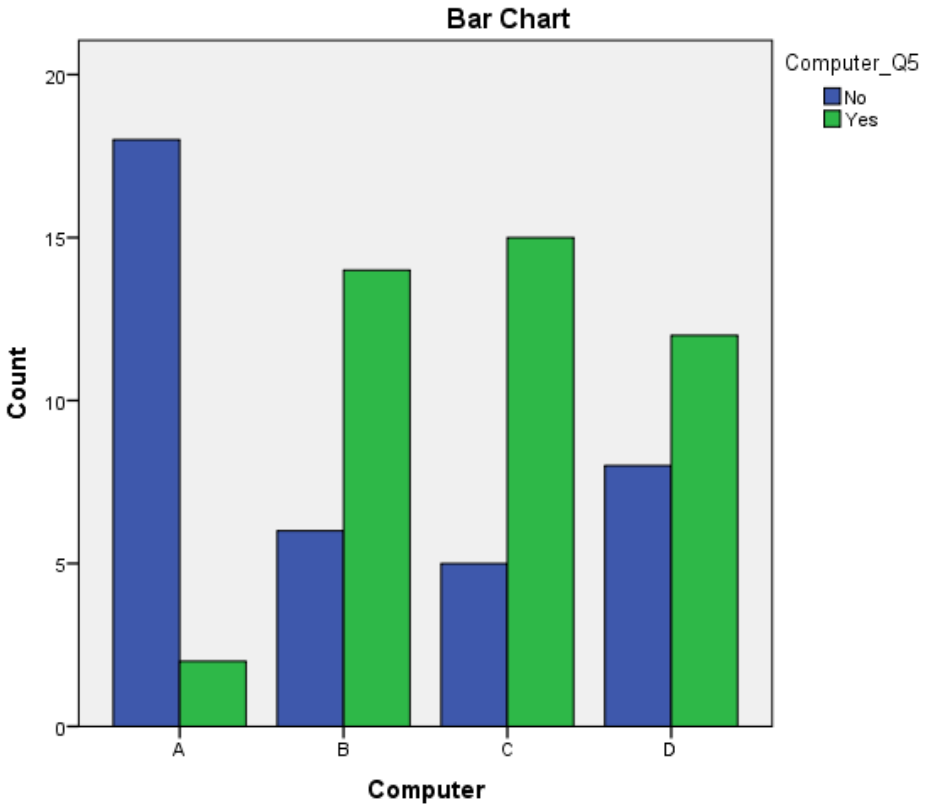
			Computer_Q4		
			No	Yes	Total
Computer	A	Count	20	0	20
		% within Computer	100.0%	0.0%	100.0%
	B	Count	16	4	20
		% within Computer	80.0%	20.0%	100.0%
	C	Count	14	6	20
		% within Computer	70.0%	30.0%	100.0%
	D	Count	7	13	20
		% within Computer	35.0%	65.0%	100.0%
Total		Count	57	23	80
		% within Computer	71.3%	28.8%	100.0%



Computer * Computer_Q5

Crosstab

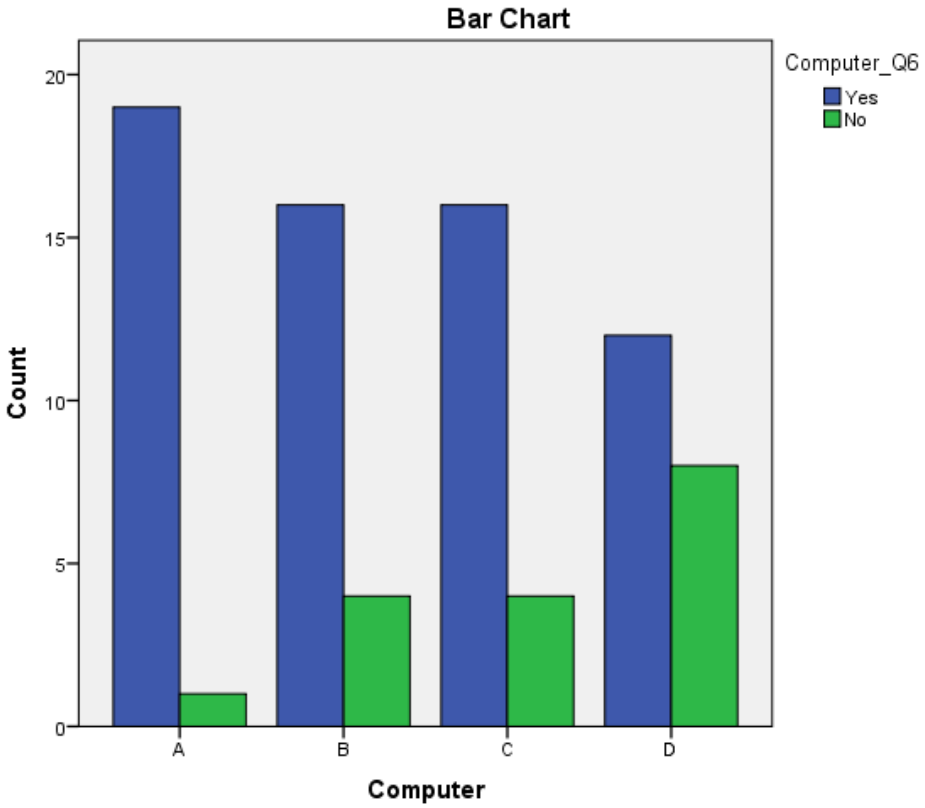
			Computer_Q5		
			No	Yes	Total
Computer	A	Count	18	2	20
		% within Computer	90.0%	10.0%	100.0%
	B	Count	6	14	20
		% within Computer	30.0%	70.0%	100.0%
	C	Count	5	15	20
		% within Computer	25.0%	75.0%	100.0%
	D	Count	8	12	20
		% within Computer	40.0%	60.0%	100.0%
Total		Count	37	43	80
		% within Computer	46.3%	53.8%	100.0%



Computer * Computer_Q6

Crosstab

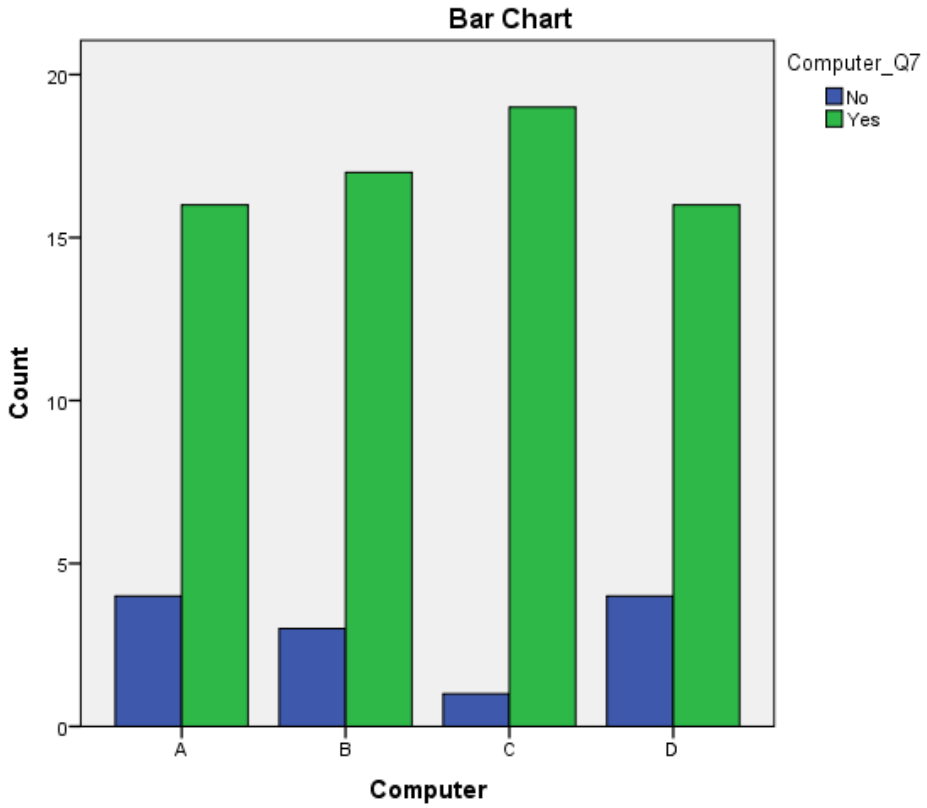
			Computer_Q6		
			Yes	No	Total
Computer	A	Count	19	1	20
		% within Computer	5.0%	95.0%	100.0%
	B	Count	16	4	20
		% within Computer	80.0%	20.0%	100.0%
	C	Count	16	4	20
		% within Computer	80.0%	20.0%	100.0%
	D	Count	12	8	20
		% within Computer	60.0%	40.0%	100.0%
Total		Count	63	17	80
		% within Computer	78.8%	21.3%	100.0%



Computer * Computer_Q7

Crosstab

			Computer_Q7		
			No	Yes	Total
Computer	A	Count	4	16	20
		% within Computer	20.0%	80.0%	100.0%
	B	Count	3	17	20
		% within Computer	15.0%	85.0%	100.0%
	C	Count	1	19	20
		% within Computer	5.0%	95.0%	100.0%
	D	Count	4	16	20
		% within Computer	20.0%	80.0%	100.0%
Total		Count	12	68	80
		% within Computer	15.0%	85.0%	100.0%



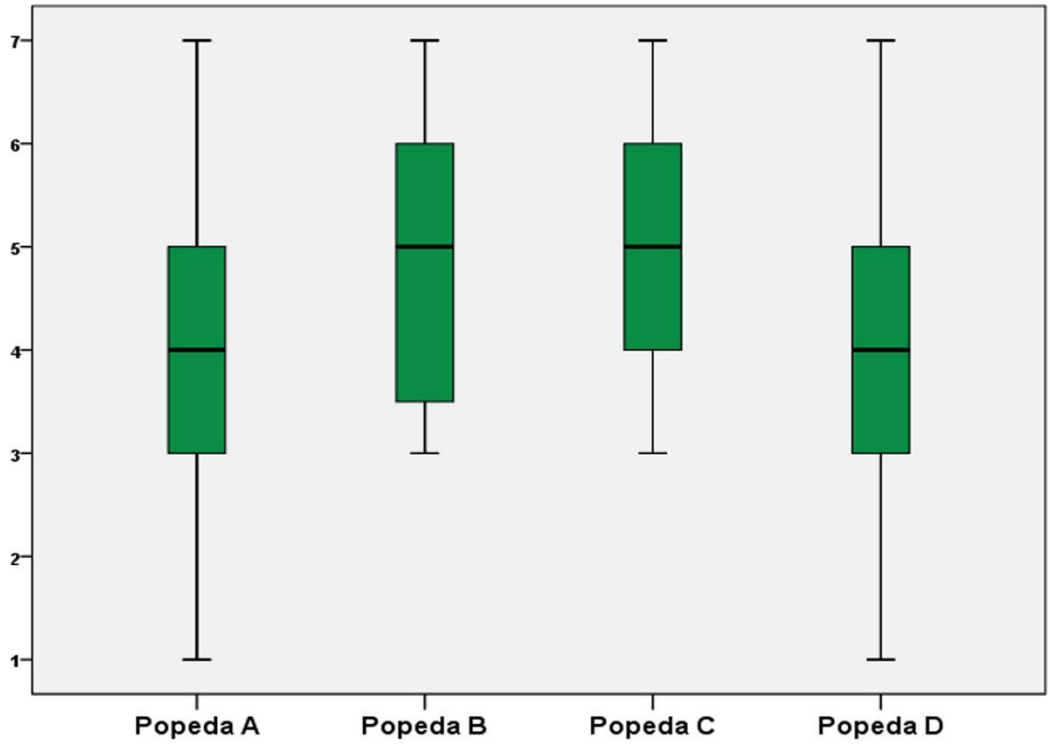
Cross Tabulation analysis for VR goggles condition

VR * VR_Q1

Crosstab

			VR_Q1							Total
			Very Un-pleasant	Moder-ately Unpleas-ant	Slightly Unpleasant	Natu-ral	Slightly Pleas-ant	Moder-ately Pleasant	Very Pleas-ant	
VR	A	Count	1	1	5	5	4	1	3	20
		% within VR	5.0%	5.0%	25.0%	25.0%	20.0%	5.0%	15.0%	100.0 %
	B	Count	0	0	5	4	5	3	3	20
		% within VR	0.0%	0.0%	25.0%	20.0%	25.0%	15.0%	15.0%	100.0 %
	C	Count	0	0	2	6	6	3	3	20
		% within VR	0.0%	0.0%	10.0%	30.0%	30.0%	15.0%	15.0%	100.0 %

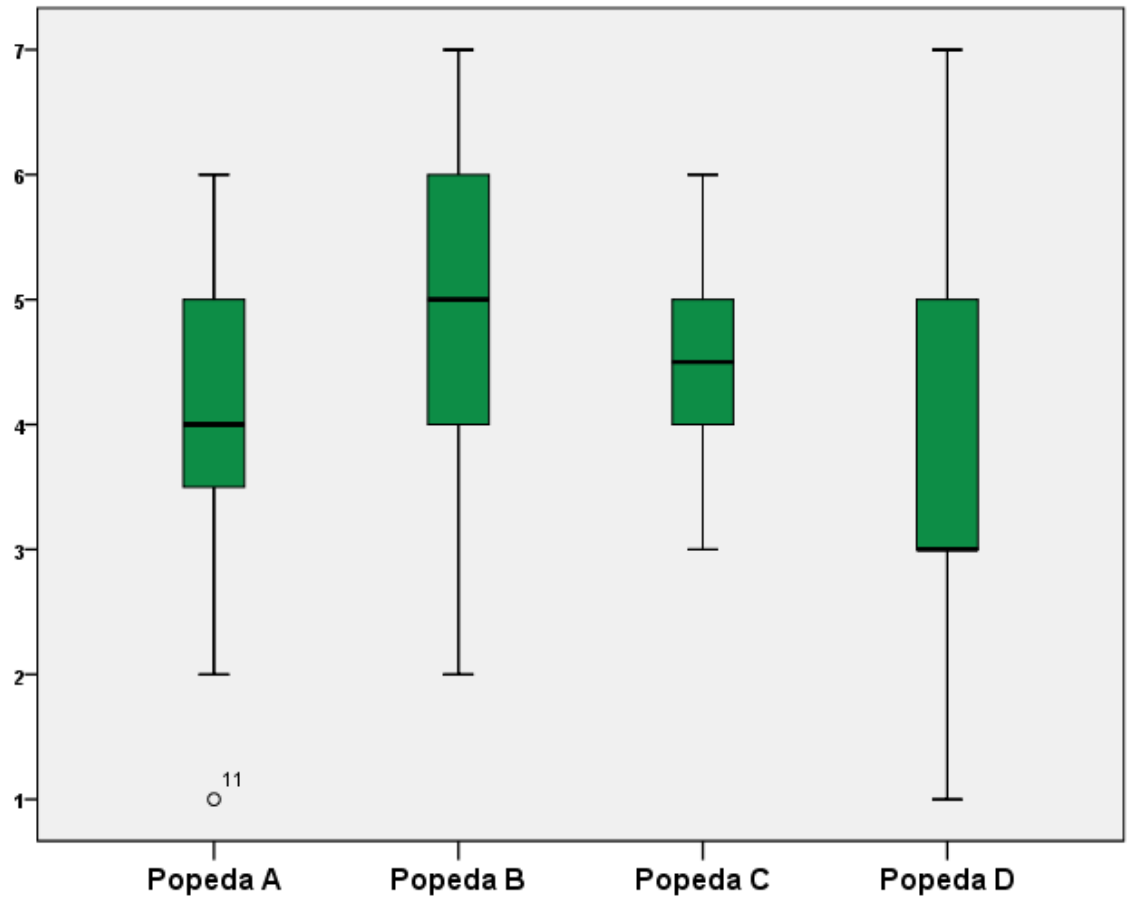
	D	Count	1	2	6	4	3	1	3	20
		% within VR	5.0%	10.0%	30.0%	20.0%	15.0%	5.0%	15.0%	100.0 %
Total		Count	2	3	18	19	18	8	12	80
		% within VR	2.5%	3.8%	22.5%	23.8%	22.5%	10.0%	15.0%	100.0 %



VR * VR_Q2

Crosstab

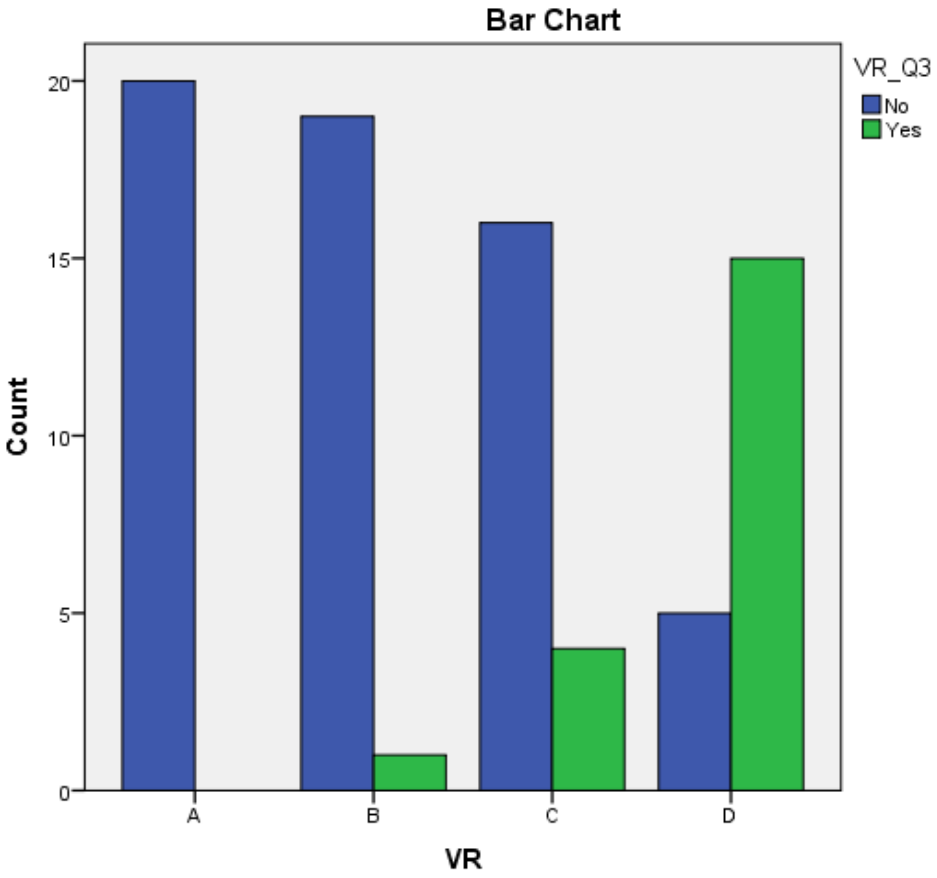
			VR_Q2							Total
			Very Bad	Moderate-ly Bad	Slightly Bad	Natu-ral	Slightly Good	Moderate-ly Good	Very Good	
VR	A	Count	1	2	2	6	5	4	0	20
		% within VR	5.0%	10.0%	10.0%	30.0%	25.0%	20.0%	0.0%	100.0 %
	B	Count	0	1	2	5	6	5	1	20
		% within VR	0.0%	5.0%	10.0%	25.0%	30.0%	25.0%	5.0%	100.0 %
	C	Count	0	0	1	9	7	3	0	20
		% within VR	0.0%	0.0%	5.0%	45.0%	35.0%	15.0%	0.0%	100.0 %
	D	Count	1	0	10	2	4	2	1	20
		% within VR	5.0%	0.0%	50.0%	10.0%	20.0%	10.0%	5.0%	100.0 %
Total		Count	2	3	15	22	22	14	2	80
		% within VR	2.5%	3.8%	18.8%	27.5%	27.5%	17.5%	2.5%	100.0 %



VR * VR_Q3

Crosstab

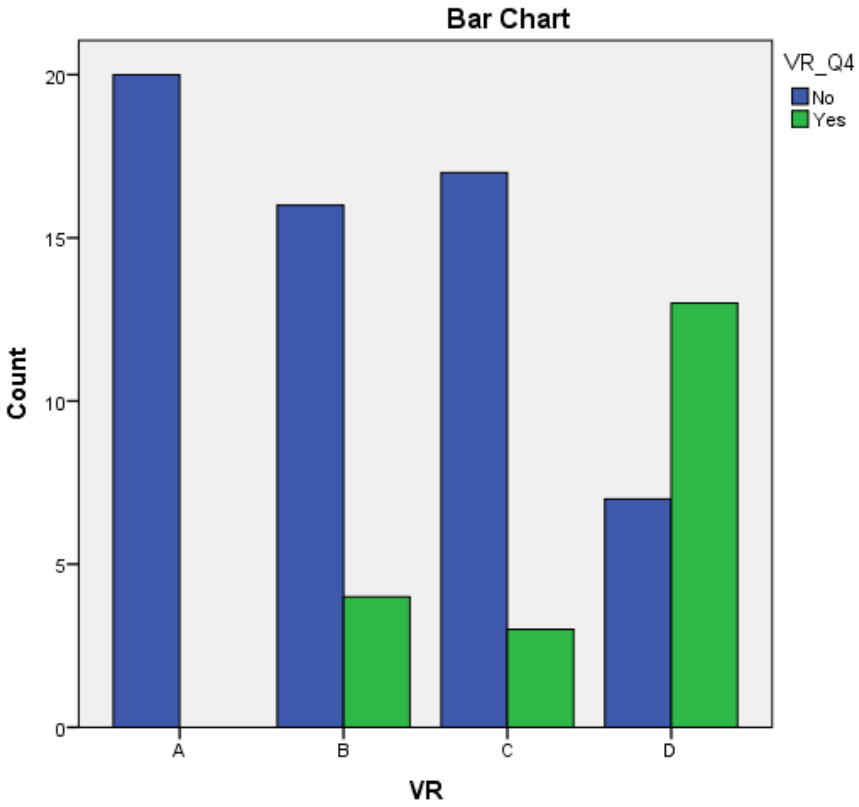
			VR_Q3		
			No	Yes	Total
VR	A	Count	20	0	20
		% within VR	100.0%	0.0%	100.0%
	B	Count	19	1	20
		% within VR	95.0%	5.0%	100.0%
	C	Count	16	4	20
		% within VR	80.0%	20.0%	100.0%
	D	Count	5	15	20
		% within VR	25.0%	75.0%	100.0%
Total		Count	60	20	80
		% within VR	75.0%	25.0%	100.0%



VR * VR_Q4

Crosstab

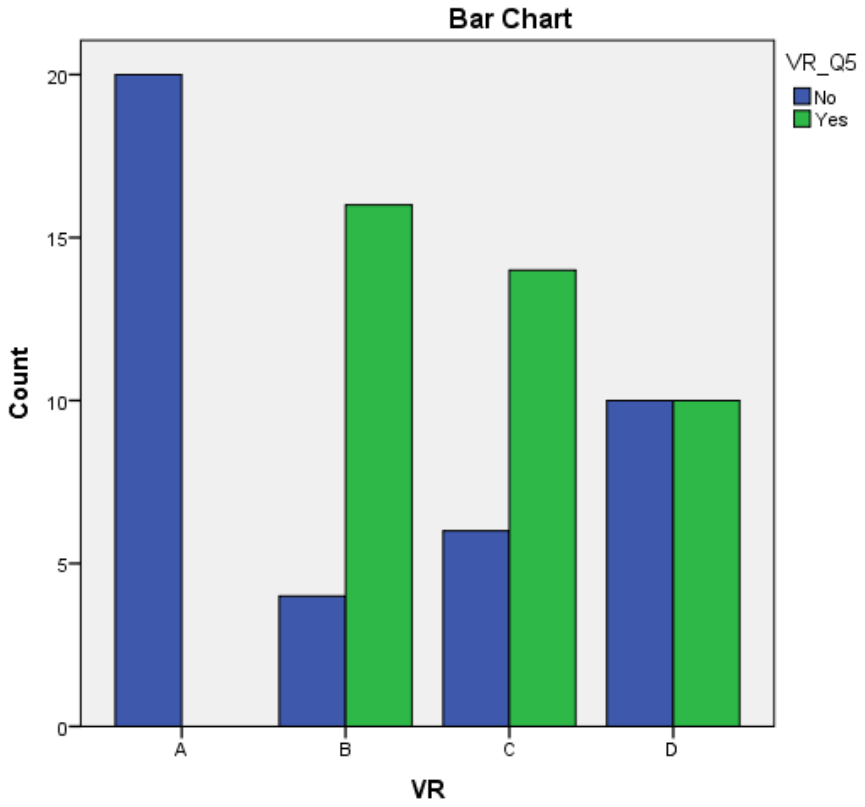
			VR_Q4		
			No	Yes	Total
VR	A	Count	20	0	20
		% within VR	100.0%	0.0%	100.0%
	B	Count	16	4	20
		% within VR	80.0%	20.0%	100.0%
	C	Count	17	3	20
		% within VR	85.0%	15.0%	100.0%
	D	Count	7	13	20
		% within VR	35.0%	65.0%	100.0%
Total		Count	60	20	80
		% within VR	75.0%	25.0%	100.0%



VR * VR_Q5

Crosstab

			VR_Q5		
			No	Yes	Total
VR	A	Count	20	0	20
		% within VR	100.0%	0.0%	100.0%
	B	Count	4	16	20
		% within VR	20.0%	80.0%	100.0%
	C	Count	6	14	20
		% within VR	30.0%	70.0%	100.0%
	D	Count	10	10	20
		% within VR	50.0%	50.0%	100.0%
Total		Count	40	40	80
		% within VR	50.0%	50.0%	100.0%

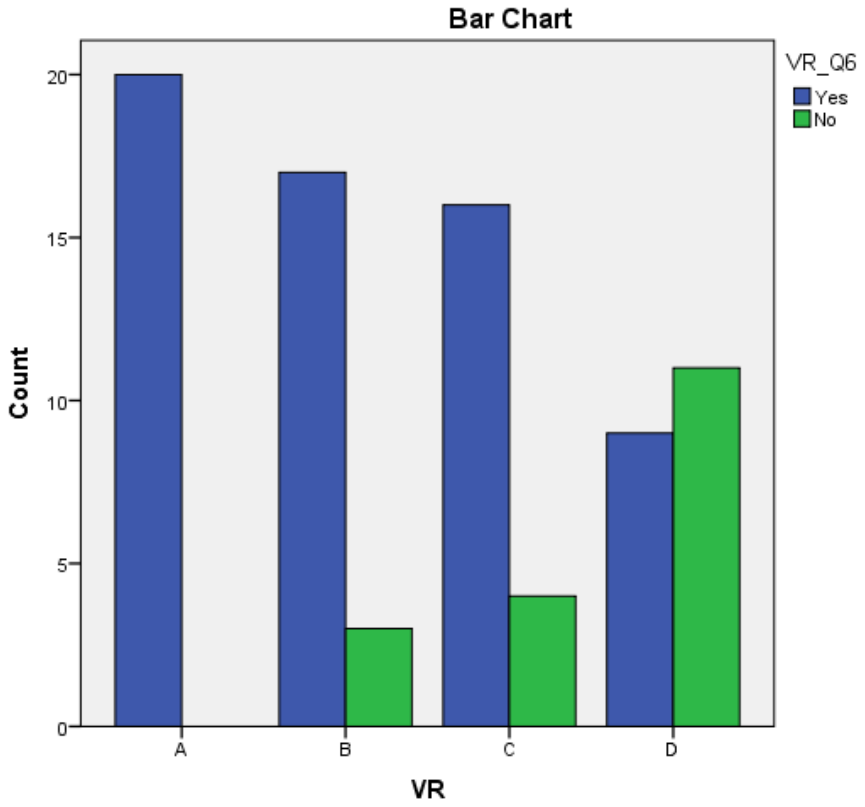


VR * VR_Q6

Crosstab

			VR_Q6		
			Yes	No	Total
VR	A	Count	20	0	20
		% within VR	100.0%	0.0%	100.0%
	B	Count	17	3	20
		% within VR	85.0%	15.0%	100.0%
	C	Count	16	4	20
		% within VR	80.0%	20.0%	100.0%
	D	Count	9	11	20
		% within VR	45.0%	55.0%	100.0%

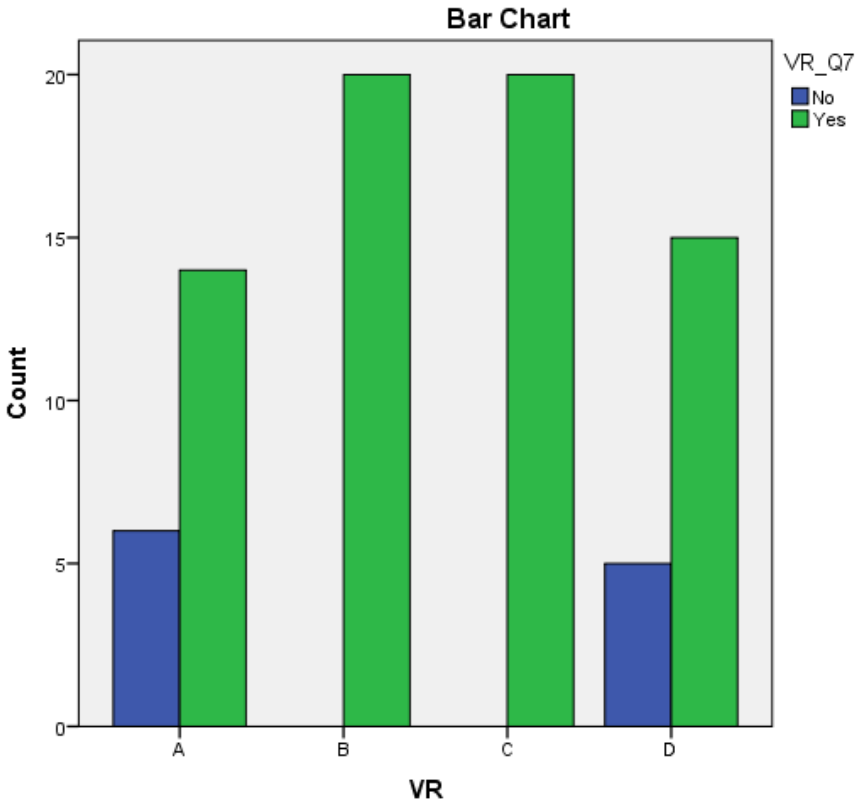
Total	Count	62	18	80
	% within VR	77.5%	22.5%	100.0%



VR * VR_Q7

Crosstab

			VR_Q7		
			No	Yes	Total
VR	A	Count	6	14	20
		% within VR	30.0%	70.0%	100.0%
	B	Count	0	20	20
		% within VR	0.0%	100.0%	100.0%
	C	Count	0	20	20
		% within VR	0.0%	100.0%	100.0%
	D	Count	5	15	20
		% within VR	25.0%	75.0%	100.0%
Total		Count	11	69	80
		% within VR	13.8%	86.3%	100.0%



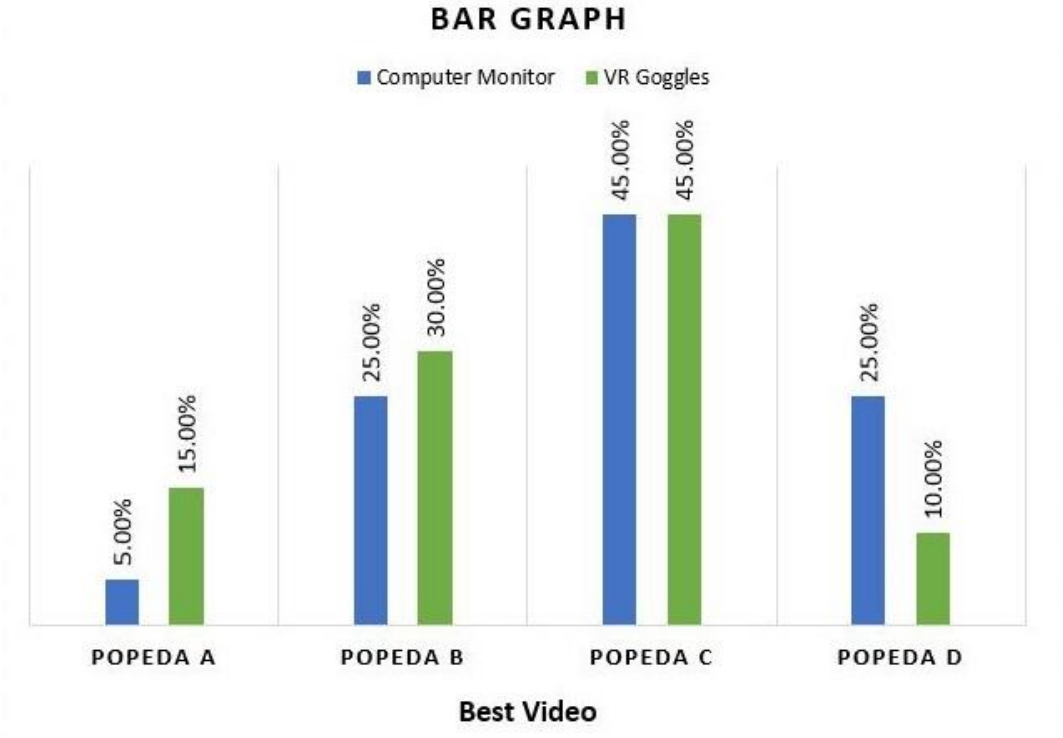
Cross Tabulation analysis for Best Video Ranking

BEST_1 * VIDEOS

Crosstab

			VIDEOS		
			Computer	VR	Total
BEST_1	A	Count	1	3	4
		% within VIDEOS	5.0%	15.0%	10.0%
	B	Count	5	6	11
		% within VIDEOS	25.0%	30.0%	27.5%
	C	Count	9	9	18
		% within VIDEOS	45.0%	45.0%	45.0%

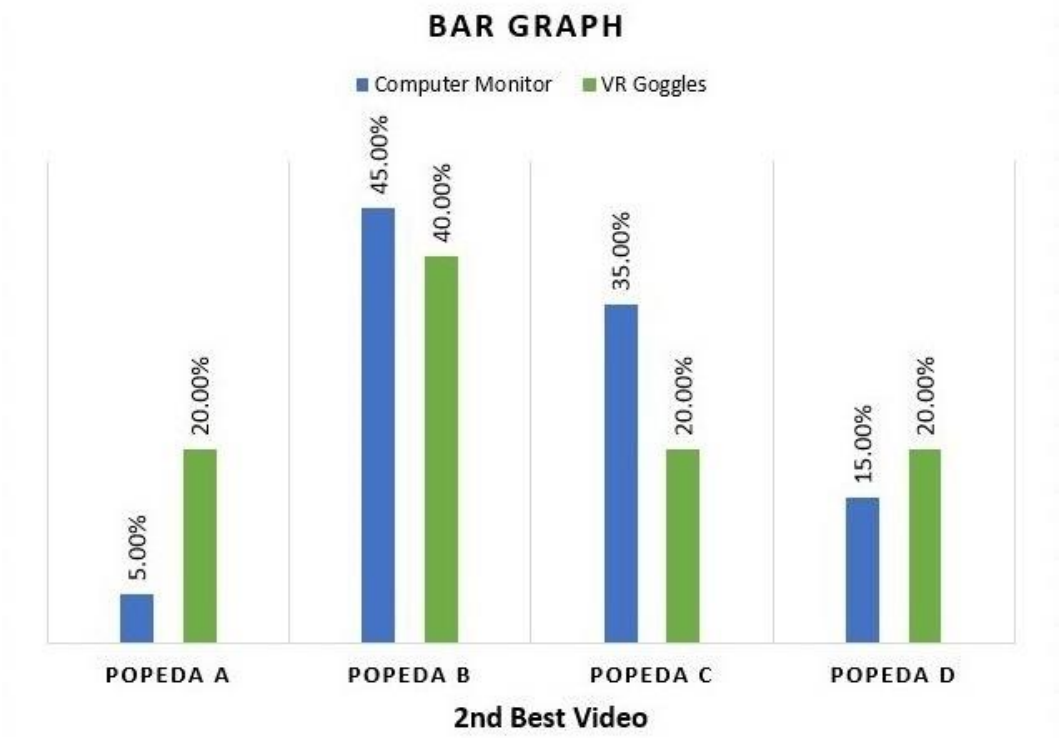
	D	Count	5	2	7
		% within VIDEOS	25.0%	10.0%	17.5%
Total		Count	20	20	40
		% within VIDEOS	100.0%	100.0%	100.0%



BEST_2 * VIDEOS

Crosstab

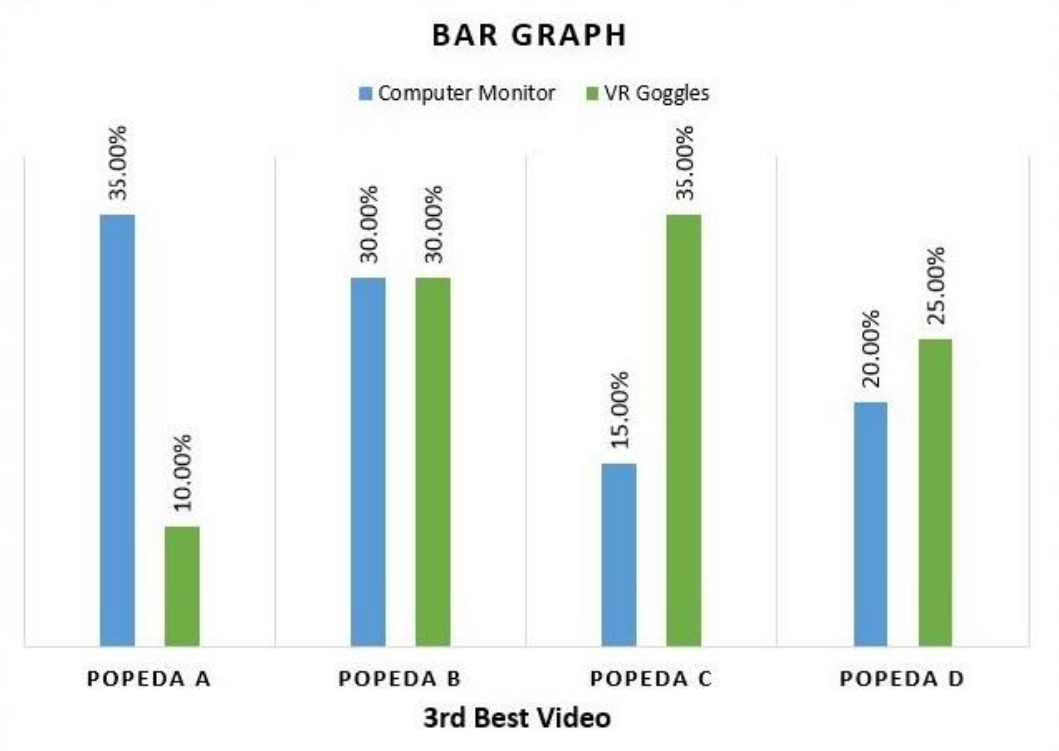
			VIDEOS		
			Computer	VR	Total
BEST_2	A	Count	1	4	5
		% within VIDEOS	5.0%	20.0%	12.5%
	B	Count	9	8	17
		% within VIDEOS	45.0%	40.0%	42.5%
	C	Count	7	4	11
		% within VIDEOS	35.0%	20.0%	27.5%
	D	Count	3	4	7
		% within VIDEOS	15.0%	20.0%	17.5%
Total		Count	20	20	40
		% within VIDEOS	100.0%	100.0%	100.0%



BEST_3 * VIDEOS

Crosstab

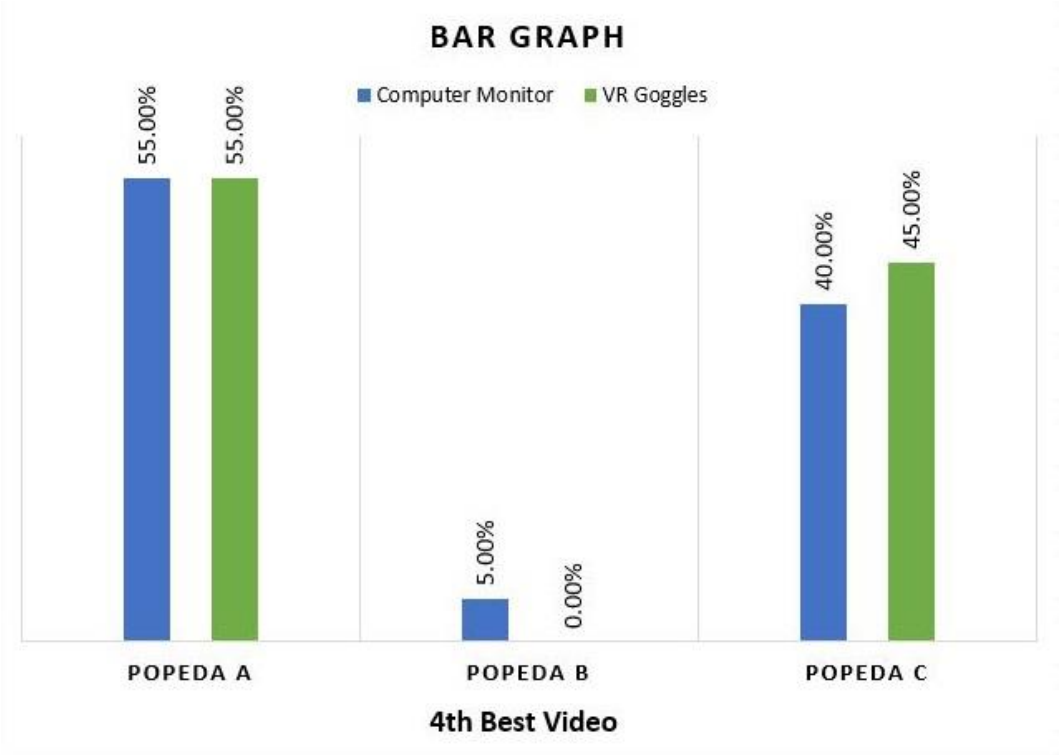
			VIDEOS		
			Computer	VR	Total
BEST_3	A	Count	7	2	9
		% within VIDEOS	35.0%	10.0%	22.5%
	B	Count	6	6	12
		% within VIDEOS	30.0%	30.0%	30.0%
	C	Count	3	7	10
		% within VIDEOS	15.0%	35.0%	25.0%
	D	Count	4	5	9
		% within VIDEOS	20.0%	25.0%	22.5%
Total		Count	20	20	40
		% within VIDEOS	100.0%	100.0%	100.0%



BEST_4 * VIDEOS

Crosstab

			VIDEOS		
			Computer	VR	Total
BEST_4	A	Count	11	11	22
		% within VIDEOS	55.0%	55.0%	55.0%
	C	Count	1	0	1
		% within VIDEOS	5.0%	0.0%	2.5%
	D	Count	8	9	17
		% within VIDEOS	40.0%	45.0%	42.5%
Total		Count	20	20	40
		% within VIDEOS	100.0%	100.0%	100.0%


BAR GRAPH
Computer Monitor
VR Goggles
55.00%
55.00%
5.00%
0.00%
40.00%
45.00%
POPEDA A
POPEDA B
POPEDA C
4th Best Video